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THE UNITED NATIONS AND THE PEACEFUL USES OF ATOMIC ENERGY

IN a broadcast address at the end of last year on man's peril from the hydrogen bomb, Lord Russell expressed the opinion that the human race had reached a point when it must abandon war as an instrument of policy or accept the possibility of total destruction. It was essential for this to be understood on both sides of the Iron Curtain, and he suggested that one or more neutral powers should appoint a commission of experts, all neutrals, to prepare a report on the destructive effects to be expected in a war with hydrogen bombs, among neutrals as well as among belligerents. This report was to be presented to the Governments of all the Great Powers with an invitation to express their agreement or disagreement with its findings. In this way, he thought, all the Great Powers could be led to agree that a world war could no longer serve the purposes of any of them, since it would be likely to exterminate friend and foe alike as well as neutrals.

The essential point of this appeal—that we must learn to think in a new way because in any future war nuclear weapons will certainly be employed and their use threatens the continued existence of mankind—is reiterated in a statement made public by Lord Russell on July 9. The statement, which was signed by Lord Russell, Prof. P. W. Bridgman, Prof. Albert Einstein, Prof. L. Infeld, Prof. J. F. Joliot-Curie, Prof. H. J. Muller, Prof. C. F. Powell, Prof. J. Rotblat and Prof. H. Yukawa, was sent simultaneously to Sir Anthony Eden, President Eisenhower, Marshal Bulganin, Mr. Chou En-lai, President Coty of France and Mr. St. Laurent, the Prime Minister of Canada. The statement concludes with a draft resolution which, it is suggested, could be adopted by a conference of scientists summoned to determine impartially and without political prejudice the facts about the consequences of exploding nuclear weapons. This resolution urges the Governments of the world to acknowledge publicly that their purposes cannot be furthered by a world war, and consequently to find peaceful means for the settlement of all matters in dispute between them.

The resolution is, in essence, a recapitulation, in a new context, of the Kellogg Pact for the renunciation of war as an instrument of national policy. Proposals for a conference of scientists received incidental mention in the debates in Parliament on defence early this year, and in one form such a conference was warmly supported in an outstanding speech by the Archbishop of Canterbury. Much confused thinking was evident, however, over the issues involved, nor has the confusion been removed when the proposal has been made in connexion with what is popularly known as "Atoms for Peace", though a symposium of articles, including an introduction by Lord Russell, contributed to the ninetieth anniversary issue of the New York periodical, *The Nation*, under that title should assist to clarify thought.

The problem of nuclear weapons and their control or renunciation is seen in its true perspective not so much against the special problems of nuclear power and its potentialities for mankind, as against the historical background of such proposals as the Kellogg Pact and the attempts of the League of Nations to achieve disarmament. An understanding of the reasons for these earlier failures illuminates the failure of post-war efforts to achieve a practical scheme for the control of nuclear weapons and may, perhaps, suggest a promising line of advance. Indeed, it will be noted that this new appeal by Lord Russell specifically contemplates an agreement to renounce nuclear weapons as part of a general reduction of armaments.

The celebration of the tenth anniversary of the signing of the Charter of the United Nations at San Francisco appeared to attract little real interest in Great Britain; but a review of the ten years experience of the working of the United Nations may have some value in assessing the usefulness of some of the suggestions made regarding international agreement on atomic energy and in overcoming the difficulties which at present hinder its realization. It should be remembered, moreover, that, in spite of the unique character of the San Francisco Conference, which was attended by delegates of fifty nations, all of whom exercised their vote on the Charter, no extravagant hopes were entertained. There was a sober realization that no international instrument or constitutional specific would suffice of itself to maintain peace.

That much has been fully attested by ten years of what was to be a real regime of collective security under the responsibility of the Security Council, and by a concerted effort under the General Assembly to promote world welfare and particularly that of the lesser-developed or privileged parts of the world. Wherever the Great Powers were prepared to use the Council constructively, the United Nations organization has functioned as an instrument of peace, and to some extent the obstructiveness and negative attitude of the Soviet Union have been offset by the greater readiness of the United States to co-operate and to assume responsibilities of leadership. Moreover, special regional organizations under the ægis of the United Nations have come into being to offset the limitations imposed on the Security Council by the restrictive use of the veto.

On the welfare side, too, there have been disappointments, where the General Assembly and the Special Agencies responsible to it, such as the United Nations Educational, Scientific and Cultural Organization, the Food and Agriculture Organization and so on, have been used irresponsibly or diffusely. As under the League of Nations, the technical organizations have indeed proved far more successful than the political agencies in achieving co-operation and

understanding; and for all the disappointments, much more progress has been made by the United Nations as a centre for international welfare than might have been expected ten years ago. However, it must be recognized that some of the important developments have come from outside the United Nations, notably the Point Four Plan of President Trueman, the Colombo Plan for Co-operative Economic Development in South and South-East Asia and the earlier Marshall Aid from which President Trueman's proposals arose.

At times it has seemed doubtful whether the lessons of military and economic co-operation in the Second World War have been learned. The trusteeship system has proved disappointing, largely through the way in which it has been used by those who bore no responsibility for the consequences of their words. If, however, the hopes originally entertained in regard to research and the encouragement of development have been falsified, much that it was hoped might have taken place under the Trusteeship Council has come into being outside the United Nations; thus a noteworthy advance towards co-ordination and co-operation in research has been made in Africa in this decade. Moreover, even when used irresponsibly, the United Nations and its Agencies have proved a medium for the constant and thorough interchange of thought and ideas which, as wisdom is acquired in their use, should increasingly promote a better and more tolerant understanding among nations and among peoples.

With the work of most of these Specialized Agencies many scientists have been closely concerned, and whatever reservations may be felt about some aspects of the work of the United Nations Educational, Scientific and Cultural Organization, it has probably assisted the International Scientific Unions to function earlier and more widely than might otherwise have happened. It has also contributed notably to the task of creating a world opinion which clearly understands the price to be paid for peace, and the restraints to be accepted as the alternative to anarchy—indeed, the limitations as well as the opportunities of world organization. Such an informed opinion, clearly understanding what is involved, is the first condition for any world organization to function effectively.

If, however, the celebrations at San Francisco on June 26, when all the Great Powers, save China, were represented by their Foreign Ministers, together with those of thirty-four other States, justify greater confidence that this is being achieved, it is probably due less to the work of the United Nations itself than to what has flowed from the advent of nuclear weapons of war. It is not always realized that when the Charter of the United Nations was signed, the atomic bomb was unknown to the world at large, and only slowly have the tremendous implications which nuclear fission may hold for the future of civilization been grasped. That in recent months the nature of the choice which faces mankind has become clear is due at least in part to scientists who have recognized their special responsibilities, in addition to their common rights as citizens, and used their opportunities to let the world know, in the light of their intimate and expert knowledge, their views on the uses which the world should make of this great new gift of science to mankind, and both its promise and its threat to humanity.

The prescience of Sir Henry Dale's observations in 1945 on this subject, and on the implications of nuclear fission and the conditions under which it was achieved, both for science and for humanity, made in his presidential address that year to the Royal Society, have been amply attested, and many current proposals might well be considered in their context. The nations have, as Sir Henry remarked, to decide how they intend to use the powers and resources which science stands ready to offer in growing abundance. Either they must let science work again and henceforward in freedom, as an international community, and use what it offers for raising all mankind to new levels of material prosperity and of culture, or, by binding science to secrecy for the competitive invention of more effective means of destruction, they can hold civilization in instant peril of dissolution.

That alternative the Conference on the Peaceful Uses of Atomic Energy, opening in Geneva on August 8, may be expected to emphasize, in spite of the dominantly technical character of the papers to be presented. Indeed, the range of technical topics to be discussed should of itself demonstrate the importance of full and free discussion for the advance of both science and technology, and help to break down the secrecy in which nuclear science has been shrouded and the effects of which are as detrimental to science itself as they are to international relations and understanding between peoples. Nor should it be forgotten that scientists are already inquiring into the biological hazards of radiation, and there is no reason for anticipating that, in the present climate of opinion, their findings will not be presented to the world in much the same way that Lord Russell and his co-signatories suggest in respect of nuclear warfare generally. The Government has already promised to publish the Medical Research Council's report on the subject as a White Paper.

A glance over the ten years work of the United Nations thus facilitates sound judgments as to the prospects and possibilities of the recent Geneva Conference of the Great Powers, of that on Peaceful Uses of Nuclear Energy, and of proposals such as Lord Russell and his co-signatories have sponsored, and the similar resolutions passed by eighteen Nobel Prize winners during the course of a meeting held at Mainau on July 15. Of the three broad conceptions which went to the shaping of the United Nations and its activities, it is fair to say that only one—that of the United Nations as a centre of economic and technological activity—has stood the test of this decade. The hopes for the organization as a body bound together by the observance of certain standards of international decency have, by and large, proved illusory, as also those of it as an attempt to "put teeth into the Covenant of the League of Nations".

But even these two conceptions have not been quite without value. In certain conditions, the United Nations is clearly capable of keeping the peace, and, given agreement and mutual understanding between the two great blocks of nations, it could largely achieve its declared purposes. It is equally clear that such agreement does not yet fully exist, in spite of the Geneva Conference. The world would indeed be in much worse shape without the United Nations, which remains as a place where the two great power blocks and those who try to be neutral can come together to find ways of reconciling their different outlooks before it is too late.

Nor is this all. There is some evidence, and not least in the talks at the recent Four-Power Conference at Geneva, that some international standards are gaining wide acceptance, at least to the extent of lip-service if not actual practice. That process might be encouraged if there were less disposition to be critical, and if the critics were more careful that their own practice matched the standards they advocate. Co-existence implies tolerance; but what is required above all is realism—a clear recognition of what the United Nations can, and cannot, do.

Two positive aspects in particular seem important in considering appeals such as Lord Russell and others have launched. The United Nations, as has just been indicated, has demonstrated its value as a forum for the discussion of international problems and the creation of world opinion. This is a slow process; but it is important that all that is possible should be done to assist and accelerate it. Secondly, the United Nations and its Specialized Agencies have demonstrated their value as a potential force for the dissemination of technical knowledge and assistance. Their effectiveness in that respect will be increased as they are more wisely used, and as greater care is taken to increase the efficiency with which such non-political activities are organized.

Lord Russell's appeal does not appear to show full cognizance of this position. In thanking Lord Russell for his letter, the Prime Minister wrote that he agreed that only the abolition of war could finally remove the perils which threaten the future of mankind, and welcomed the recognition in the statement that it is war itself and not simply nuclear weapons which must be abolished, and that the renunciation of nuclear weapons must form part of a general reduction of armaments. What the statement fails to do, however, is to make clear that this is the policy which the British Government has consistently followed. It is also important to note the reservation which Prof. F. J. Joliot-Curie made regarding the suggestion that war should be abolished. It reveals how far we are still from convincing those on the eastern side of the Iron Curtain that nuclear war involves universal destruction.

The problem which this division involves is not fairly faced by Lord Russell and his co-signatories; though if all the leading Governments could be brought to subscribe to the declaration only good could result. None the less, the educational value of the statement is important and that can equally be said of the "Atoms for Peace" issue of *The Nation* and of a pamphlet "Atoms for Peace—not War" (published by Science for Peace, 16 Ulster Place, London, W.C.1. Pp. 31. 1*s*.) prepared by a group of scientists who believe that the threat of nuclear warfare can be removed. The latter pamphlet, to which Prof. C. F. Powell contributed a foreword, gives a brief review of the present situation in regard to the peaceful use of nuclear energy and of the discussions on abolition of nuclear weapons before summarizing the extent of agreement on international control. This account, however, is a little biased against the United States, and the suggestion that insistence on international ownership is the real obstacle, rather than the objection of the U.S.S.R. to a system of inspection and refusal to accept any sacrifice of national sovereignty, is unrealistic. The treatment of President Eisenhower's original "Atoms for Peace" proposal of December 8, 1953, is likewise ungenerous; but with those reservations the pamphlet indicates clearly the stage which has been reached in negotiation and the really decisive changes since the first proposals for the control of nuclear energy were made in 1946.

Those changes are the disappearance of the monopoly of nuclear weapons by the United States; the development of thermonuclear weapons by both the United States and the U.S.S.R.; the extensive development of means of delivering nuclear weapons using unpiloted rockets and the availability of such weapons to ground forces; and above all the devising of a 'breeding' process for atomic piles which has made development of large-scale nuclear power economic. The "Atoms for Peace" issue of *The Nation* is concerned more especially with these latter implications, and includes in particular an article by J. G. Beckerley, director of classification of the U.S. Atomic Energy Commission for five years, on the importance of limiting secrecy requirements to the minimum.

Scientists can probably best contribute to the education of the community as to the implications of nuclear weapons and the sacrifices or restraints on national sovereignty that are involved by articles such as that on the hydrogen–uranium bomb contributed by Prof. J. Rotblat to the *Bulletin of the Atomic Scientists* last May, or by Prof. M. Westergaard on "Man's Responsibility to his Genetic Heritage" in the June issue of *Impact of Science on Society*, rather than by such statements as that which Lord Russell has sponsored, or the Nobel Prize winners' appeal already referred to. Something beyond technical papers will be required before we can, as Sir Richard Livingstone has said, master atomic energy, and see that civilization is enriched and not cheapened by the indiscriminate gifts of technology, while the most difficult problems, economic, social, political and moral, are pressing for solution.

None the less, the contribution of science must be primarily factual, though imaginatively alive to the human social issues and keenly aware of the experience of the past gained not only in the United Nations but in the League of Nations and earlier.

Indeed, unless injudicious and premature attempts to force a system of world government, through which alone effective control of nuclear energy could ultimately be achieved, wreck the United Nations, that organization may well play a larger part in international affairs in its second than in its first decade. Apart from its impact on military science, the development of nuclear power for peaceful purposes is likely to demand and encourage co-operation and goodwill between the nations, and thus to prepare the way for a workable system of world-wide inspection and enforcement of nuclear disarmament. Any such system will be virtually impossible except under the auspices of the United Nations, simply for the technical reasons that methods for detecting radiation must be applied all over the world, and that advances in nuclear weapons will ultimately enable the smaller States also to possess them.

Meanwhile, scientists should be considering what further constructive part they can play in the education of world opinion as to the conditions under which the world can enjoy the full benefits of nuclear power, and the imperative necessity for fresh thinking about national sovereignty and international relations in this age of technology. Apart from making clear the price which has to be paid and the discipline and restraint demanded, there are many technical problems to which they must make the decisive contribution. Some of these problems are to be discussed at Geneva in the forthcoming Conference on the Peaceful Uses of Atomic Energy. There are many others, some of which have political aspects in which the scientific or technical contribution is equally decisive. While the preparation of world opinion for the sacrifice of national sovereignty proceeds, constructive thought is needed as to the details of an effective inspection system, for example, which would provide a practical alarm, without seriously hampering the conduct of internal affairs or invoking large surrender of sovereignty. Clear thought as to the essentials which should be known might well enable a small group of inspectors, at key points, to provide the surveillance of major production activities which would provide ample warning of mobilization, for example.

The contribution of science to world peace and the utilization of nuclear energy should be essentially practical. Apart from the task of education and of giving clear warning of the dangers attendant on abuse of the powers which are now placed in man's hands, it should above all be mindful of the conditions upon which the advance of science itself depends. In proportion as full freedom of interchange of knowledge across frontiers is re-established and science regains its international position, the risk of misunderstanding and abuse will diminish. A first duty of every scientist, and the most important contribution he can render to the cause of peace, is to take up the challenge which Sir Henry Dale threw down at the anniversary meeting of the Royal Society when the United Nations was but a few months old.

ORIGINS OF THE TORSION BALANCE

Roland Eötvös

Gesammelte Arbeiten. Herausgegeben von P. Selényi. (Im Auftrage der Ungarischen Akademie der Wissenschaften.) Pp. lxxx+384. (Budapest: Akadémiai Kiado, 1953.) n.p.

THIS volume contains eleven of the principal papers of Baron Roland Eötvös (1848–1919). The reputation of Eötvös as a physicist rests on two really original ideas worked out over a period of thirty years with great skill and thoroughness. The first idea concerns the forces acting on a torsion balance. Eötvös realized that even when no outside couple was deliberately applied, the variation in the direction of gravity from one end of a suspended beam to the other would produce a couple, and that this couple could be detected and measured if the whole instrument, including the torsion head and the case, were turned into several azimuths in succession, and the position of the beam relative to the case noted in each. The couples depend on the space gradients of the components of the force of gravity, of which only five are independent. Eötvös showed that four of these quantities could be obtained from the measurements and that these were equivalent to determining the rate of change of the force of gravity along a level surface, the difference of the two principal curvatures of the level surface and the directions of the principal curvatures. All this is worked out in his papers with the greatest completeness.

Having demonstrated that the torsion balance would measure the gradients of gravity, he developed a portable instrument and applied it to geological problems, in particular to the search for oil-bearing structures in Hungary. After the death of Eötvös, the instrument was widely used in the United States and elsewhere; but from about 1937 its use rapidly declined in favour of the gravimeter, partly because of the much greater speed of operation of the latter and partly because of the lesser disturbance which it suffers from very local irregularities in density. It is possible that the present neglect of the instrument is a passing phase and that, if the speed of operation were increased by the use of electronic techniques, it might again find applications.

The second original idea of Eötvös was that the torsion balance could give a very precise verification of the constancy of the ratio of gravitational to inertial mass. His method depends on the 'force of gravity', as observed on the earth, being compounded of a part due to the attraction of the earth, and a part due to rotation. The former depends on gravitational mass, the latter on inertial. If the ratio is not the same for the masses at the two ends of the beam of a torsion balance, the beam will experience a couple. The extreme sensitivity of the balance enables a limit of about one part in 10^9 to be set to the variation of the ratio from one substance to another.

These are the main themes of the work of Eötvös, though in reading the papers one finds many other beautiful things; for example, a demonstration that a sheet of lead 5 cm. thick does not absorb the force of gravity by more than two parts in 10^{11}, and the discovery that the rate of change with temperature of the product of the surface tension of a liquid and

the two-thirds power of its molecular volume is roughly the same for all liquids.

Eötvös was clearly a man of great ability and energy, whose work has been too little known. Einstein, for example, remarks that when he first thought about the equivalence of gravity and acceleration he knew of the experiments of Newton and Bessel on gravitational and inertial mass, but not of those of Eötvös. It is to be hoped that the publication of these papers will make his work more widely known.

The book includes an interesting life of Eötvös by Paul Selényi. The delicate task of writing a foreword deriving a suitable idealogical lesson from the fact that the greatest Hungarian physicist was a baron has been undertaken by K. Novobátsky.

E. C. BULLARD

TREATISE ON INORGANIC CHEMISTRY

Comprehensive Inorganic Chemistry

Edited by Prof. M. Cannon Sneed, Prof. J. Lewis Maynard and Prof. Robert C. Brasted. Vol. 2: Copper, Silver and Gold. By J. W. Laist; pp. x + 248; 35*s*. net. Vol. 3: The Halogens. By Prof. Robert C. Brasted; pp. x + 250; 35*s*. net.

(New York: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1954.)

THE editors of this series of volumes on inorganic chemistry state that their aim is to emphasize "chemical properties and relationships and their interpretation in terms of theoretical concepts". This provides us with a canon of judgment. It is the range and depth of such interpretations that distinguish the inorganic chemistry of to-day from that of even a quarter of a century ago. Valency theory, thermodynamics and other disciplines help us to digest what used to be a great mass of unrelated facts. How far, we are entitled to ask, do these two volumes, the second and third in the series, assist our digestions?

Vol. 2, on copper, silver and gold, commences with a useful table of the physical properties of the elements in question, followed by a brief introduction in which electronic structures, valencies, etc., are discussed, and the stable and radioactive isotopes are tabulated. It then deals with each Group I*B* element in turn. Nearly half the pages are concerned with the extraction metallurgy and with the alloys of the elements—a somewhat high proportion. These sections, however, are quite well done, though one wishes that the treatment was less purely descriptive and more physico-chemical; there are, too, inaccuracies in the section on the concentration of copper ores.

The remainder of the volume consists of a compilation of facts about the chief compounds. It certainly does not go very far along the road of theoretical interpretation, and though accurate enough, it is distinctly haphazard. For example, the heats of formation of CuF_2, Ag_2S and AgF_2 will be found, but not those of any other compound, let alone any systematic discussion of the thermochemistry. Again, the radius of the cupric ion does not seem to be quoted anywhere, though that of the cuprous ion is; yet ionic sizes are fundamental to the understanding both of crystal structure and of complexes in solution. In short, although this volume contains much quite recent information, it is disappointingly old-fashioned in outlook.

After an introduction like that of Vol. 2, Vol. 3 proceeds first to the elementary halogens, including astatine; then in turn to the hydrohalides; the oxycompounds of the halogens; positive halogens, interhalogens and polyhalide anionic complexes; and finally to the pseudohalogens, such as cyanogen. It is more successful than Vol. 2 in carrying out the editors' programme of "interpretation in terms of theoretical concepts", and the choice of data seems more systematic. The much larger number of tables is a sign of this. There is good coverage, too, of the interesting new features of halogen chemistry that have been brought to light in recent years, such as the existence of positive halogen ions in solution and the solvent properties of bromine trifluoride. Technological developments—for example, in the handling of fluorine—are well described, though mention should have been made of the fact that anhydrous fluorine can be handled in glass apparatus.

The volume is unfortunately not free from blemishes. For example, it is a little sad to find the following sentences about hydrochloric acid in a modern text-book. "The equivalent conductance of a 0·001 *N* solution is 377 and is 300·5 for a 1·0 *N* solution (at 18°C.). This variation represents a change in apparent ionization from 99 to about 79 per cent". The word "apparent" may justify the letter of this statement; but in spirit it is pre-Debye–Hückel.

Nevertheless, Vol. 3 is an attractive one on the whole, and, like Vol. 2, it is well produced and remarkably free from printing errors.

H. A. C. MCKAY

FUNDAMENTALS OF PHYSICAL METALLURGY

Theoretical Structural Metallurgy

By Prof. A. H. Cottrell. Second edition. Pp. viii + 251. (London: Edward Arnold (Publishers), Ltd., 1955.) 25*s*. net.

DURING the seven years that have passed since the appearance of the first edition of Prof. A. H. Cottrell's book, activity in the field of physical metallurgy has been considerable. The greatest progress has been in the study of the structural defects occurring in solids, such as grain and twin boundaries, vacant lattice sites, and dislocations, and the effect of these defects on diffusion and deformation. Important work has also appeared dealing, for example, with theories of metallic cohesion, the distribution of electrons in alloys, ferromagnetism, and the electronic structure of transition metals. In order to accommodate much of this material in a book of approximately the same length, Prof. Cottrell has rewritten the entire text, and has included an extra chapter. Naturally, some of the original has had to be condensed or rearranged, but this has been accomplished without loss of clarity, and is offset by an increase in the number of illustrations from 96 to 132.

In the first five chapters, which lead from the structure of the atom, through interatomic forces, to the zone theory, increased emphasis has been placed on quantum mechanics in order that the band structure of metals might be more fully understood. Since these chapters lead logically to the applications

of the electron theory in Chapter 6, I feel that much of the chapter on metallic crystals, especially the nature and surface tension of grain boundaries, might well have been placed later. Chapter 6 includes superconductivity, Zener's ideas of the exchange interaction in ferromagnetism, and a more lengthy discussion of domain structures and of cohesion.

The following five chapters, which range from equilibrium and the rate of approach to equilibrium, to the equilibrium diagram, are notable for an extended treatment of the equilibrium concentration of vacancies and of the structure of liquid metals. Here also are included the Laves phases, the work of Raynor on aluminium and the transition metals, a much-enlarged section on interstitial phases, and a brief mention of Friedel's work on the bound states existing in copper, silver and gold-base alloys.

Considerable effort is being devoted at the present time to studies of diffusion in metals and alloys, being aimed especially at the mechanism of the process and the effects of grain boundaries, dislocations and chemical inhomogeneities. An understanding of the process of nucleation and growth has also been sought. A survey of this work is contained in the relevant sections.

Prof. Cottrell's eminence in the field of deformation makes the extra chapter, which is entitled "Shear Processes in Metal Crystals", most valuable. The types of diffusionless changes occurring by shear processes—such as slip, deformation twinning and the martensitic-type transformation—are described, together with the mechanism of simple shear. This leads on naturally to dislocations, to the types and properties of dislocations, spiral structures, dislocation networks, and to the Frank–Read source.

The general construction of the book remains much the same as the first edition, and the price has increased by only four shillings. It contains references up to 1954. As a work dealing with the fundamentals of physical metallurgy it can only be described as excellent, and may be recommended without qualification to all students of metallurgy. J. A. Catterall

RADIOBIOLOGY

Fundamentals of Radiobiology

By Prof. Z. M. Bacq and Peter Alexander. Pp. xii + 389 + 14 plates. (London: Butterworths Scientific Publications, 1955.) 40*s*. net.

RADIOBIOLOGY is a mixed marriage of biological and physical sciences. The offspring of this union—radiobiologists—tend to suffer with psychological complexes which arise from a difficult upbringing. Formally trained in one discipline, they usually acquire proficiency in the other by apprenticeship. They feel that this latter method seldom gives them that mastery of the fundamentals of the science which is obtained from sitting at the feet of the professor.

In "Fundamentals of Radiobiology", Prof. Z. M. Bacq, a pharmacologist representing the biological sciences, and Dr. P. Alexander, a physical chemist, have combined to produce a book which will be best appreciated by the harassed radiobiologist or aspiring radiobiologist with the psychological complex.

From both the physical and biological aspects the book is written in a clear, convincing manner. Generally accepted facts are lucidly stated, which gives the student a feeling of confidence. Theories are expounded, due weight being given to the pros and cons. The authors, having done this, usually sum up and set forth their own conclusions. This will please those who search for dogma, but may antagonize the esoteric who regard the theories as still *sub judice*.

Broadly speaking, there are four large chapters—on basic physics and physical chemistry—eight smaller chapters on various fundamental biological aspects, morphological, physiological and biochemical, and finally five small chapters on what may be called applied radiobiology, including "Observations in Human Beings". Each chapter has an extensive list of references, "The 960 original papers quoted in the bibliography represent a year's solid reading", and there are author and subject indexes. The text is freely interspersed with tables and line diagrams. These admirable qualities are marred by a number of misprints. J. F. Loutit

A SURVEY OF CURRENT PSYCHOLOGY

l'Année Psychologique

Cinquante-Quatrième année, 1954. Fascicule 1; pp. viii + 306; 1,000 francs. Fascicule 2; pp. viii + 309–618; 1,200 francs. Directeurs: Henri Piéron, Alfred Fessard et Paul Fraisse. (Paris: Presses Universitaires de France, 1954–55.)

THE 1954 volumes of "l'Année Psychologique" contain several substantial experimental papers, notably the ones on chromatic sensibility of the fovea (Galifret and Piéron), the structure of rhythm (Fraisse and Oléron) and the interpretation of the meaning of ambiguous sounds (Bresson). A particularly thorough investigation is one reported by Scherrer, Barbizet and Oudot-le Hénaff on the organization of somesthetic sensibility, in which the authors establish the minimum intervals which permit successive cutaneous stimuli to be discriminated and discuss the various allied problems that arise in determining differential thresholds.

Most of the papers deal with problems in psychophysiology, but some are concerned with 'pure' psychological topics such as the relation between powers of abstraction and mental flexibility. There is also a paper on personality and æsthetic preferences, and a shorter one on applications to the fine arts. The briefer reports cover a wide range of subjects, including leadership, psychiatric tests, studies of defence mechanisms and the statistics of measurement scales.

The critical reviews of current periodicals ensure that French readers are kept in touch with developments elsewhere—a valuable feature. Among the many reviews there is one by Henri Piéron, the senior editor of the volumes, of a recently published American work in which he remarks that the author "appears systematically to avoid all citation of authors in the French language . . . and, even of European authors in general". Piéron adds: "it seems that one seeks nowadays to give to American students the impression that America alone contributes to the development of science, an attitude symmetrical to that of the U.S.S.R.". All in all, "l'Année Psychologique" easily ranks among the best publications of its kind, both in quality and range, in contemporary psychological literature.

John Cohen

NEW HIGH-SPEED ELECTRONIC TACHISTOSCOPE

By Prof. GEORGE HUMPHREY, P. G. M. DAWE and BERNARD MANDELL
Institute of Experimental Psychology, University of Oxford

An apparatus has been devised by us for exposing two visual fields for very short time-intervals with control of the interval between them. This article is concerned not only with the description of this apparatus but also with the visual problems involved in this kind of work and with an outline of the preliminary experimental results.

Apparatus

The apparatus makes use of two banks of short-decay phosphor fluorescent tubes. There are four 6-W. tubes in a bank, and each bank illuminates a visual field which is 6 in. square. These two fields are viewed from the same window by using the conventional half-silvered mirror technique for the direct transmission of one field, and the reflexion of the other, into the observer's eyes. Fig. 1 shows a plan of the instrument.

The fluorescent tubes are operated by d.c., with the current through each tube regulated by a hard valve. This is switched on and off by applying a negative bias to the control grid which is derived from an Eccles–Jordan type of electronic switch. This switch is operated by short pulses, of less than one microsecond in width, and is d.c. coupled to the control valves so that the transition from on to off or vice versa is accomplished in less than a micro-second. The pulses for operating the electronic switches (for there are two, that is, one for each bank of tubes) are derived from electronic timing circuits operating on the flip-flop principle and embodying resistance capacitance combinations to give the necessary time-delays. The timing circuits are coupled together to give the desired sequence of switching on the closing of a trigger button, which initiates the first timing circuit. The coupling is arranged to cause lamps 1 to come on first, followed by a dark-interval, and then lamps 2. The exposure time of both sets of fluorescent tubes may be continuously varied between 200 μsec. and 0·625 sec. by a stepped switch and potentiometer. The limiting factor at the short exposures is most probably the resonance radiation decay-time of the mercury atom. At these very short exposures the light output is not particularly rectangular; but at an exposure of 1 msec. upwards fairly rectangular light pulses can be obtained. This is shown in Fig. 2*a*, which is an oscillogram of two 1-msec. light pulses separated by an interval of 1½ msec. The dark-interval between the pulses is variable over the range 0–0·625 sec., although, as shown in Fig. 2*b* (for 200-μsec. light pulses with zero dark-interval), the light pulses will overlap at zero dark-interval due to the decay and build-up times of the radiation. The light pulses were observed by using cæsium–antimony vacuum photocells connected by short low-capacity leads to the cathode-ray oscilloscope. Millisecond timing-pulses derived from a 1,000 c./s. square wave are shown superimposed on the *Y*1 beam of the oscilloscope for the purposes of measurement.

The light spectrum of the fluorescent tube is continuous, being that of the magnesium tungstate phosphor, together with the addition of the principal visual lines at 4047 and 5461 A. from the excitation

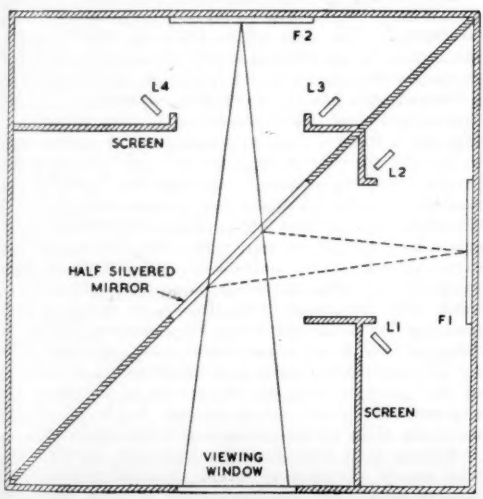

Fig. 1. Layout of the tachistoscope. Lamps *L*1, *L*2 illuminate field *F*1; *L*3, *L*4, field *F*2

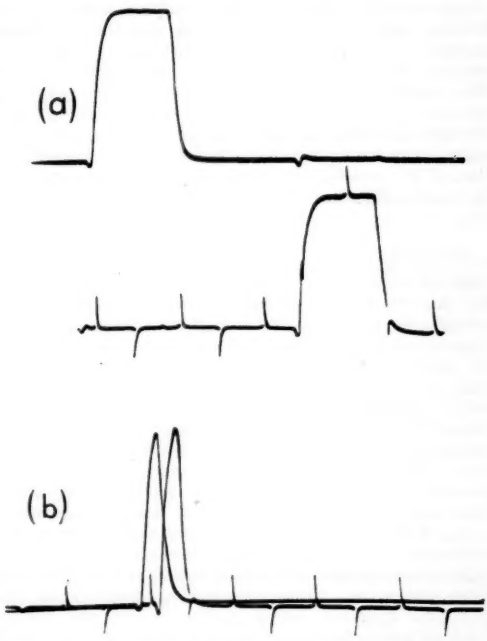

Fig. 2. (*a*) Two 1-msec. light pulses separated by a dark-interval of 1½ msec. (*b*) Two 200-μsec. light pulses with zero dark-interval

of the mercury atom. Compared with daylight, the spectrum from the tube is somewhat deficient in red light. However, it is still possible to distinguish adequately between colours even at the shortest exposure times. The actual chromaticity co-ordinates of the lamp are given as $x = 0{\cdot}230$ and $y = 0{\cdot}290$.

The intensity of light from each bank of tubes is controlled by means of a variable resistor connected in the cathode circuits of the group of power valves feeding each bank of tubes. In this way the maximum current, and therefore the brightness, of the tubes can be varied over a range of approximately 2/1. The tachistoscope may, of course, be operated repetitively from an external pulse generator, and for the purpose of visual monitoring of the light pulses it proved convenient to do this at a repetition-rate of 10 per sec., the light outputs being displayed as an oscillogram.

Visual Problems

In designing the apparatus, completely simultaneous exposure of all parts of the field was felt to be important, for modern neurophysiological considerations seem to leave open the possibility that sequential exposure may affect the manner in which an object is perceived[1–3]. The point was apparently first raised by Erdmann, more than sixty years ago, with reference to the tachistoscopes of the time, which, with the exception of those using an electric spark where the duration could not feasibly be varied, were either of the rotating wheel or other kind of moving-shutter type. In these the 'scanning' effect was said to be clearly visible, for longer exposures at least. Erdmann stated in a seminar that simultaneous exposure of the whole field with a variable exposure time was desirable but impossible. Dodge (personal communication, 1924) thought he had solved the problem with his mirror tachistoscope, the optical part of which has now become standard; but since he used a swinging pendulum as a shutter, he had really not done so.

It will be realized that in rapid exposures the phenomenal effect may be, and often is, one of complete simultaneity, when in fact the field has been scanned, either by part of a sector of a circle (Schumann) or by excursion of a rectangular slot in a moving shutter. On looking, for example, at a landscape, painted on a card, through an instrument of the circular, rotary, type in our laboratory, with an exposure of 1 msec., one sees the whole landscape appear as a single view, with no suggestion of the piecemeal and successive presentation which is actually occurring. Since the aperture was here smaller than the card, the total picture was never projected at one time on the retina. The effect is almost certainly due to some form of organic integration as the result of which a single picture is perceived when different retinal areas have been successively stimulated. This kind of process is, of course, not uncommon, the ordinary cinematographic picture being an obvious example. All this has been the subject of controversy, one side maintaining that, so long as the whole object appears simultaneously, the method of exposure is irrelevant. This conclusion is not justified *a priori* since, however clear and unitary the perceived object may be, the serial exposure and other features of this method of presentation may introduce phenomenal distortions ordinarily not noticeable, and which may prove important in accurate work. Whether this is so can only be discovered by experimental comparison of identical objects as seen by the two types of apparatus, and this is now being done. Similar considerations apply to the light pulse, which should ideally be of rectangular form. Herein lies the chief objection to the ingenious instrument of Grindley, which focuses the shutter on the lens of the eye and the object on the retina, giving indeed a view of the whole object without 'scanning' but with a light pulse far from rectangular for its time base[4]. An adaptation of this principle might, however, give good results at times shorter than are possible with Grindley's model.

It is further noteworthy that our problem is much more difficult than that of producing a short flash on an area of the retina, as for example in the experiments of Brindley and Crozier using a revolving mirror and a polarizable crystal, respectively[5,6]. In any tachistoscope a total field must be illuminated so that the effect of short exposure on complex perceptual patterns can be observed.

Apart from the manner of field-illumination of our instrument, which to our knowledge is superior to any yet built in its combination of simultaneity, very short and continuously variable exposures, together with practically rectangular light pulses from 1 msec. to 0·625 sec., an important new feature is the timed dark-interval, between the two exposures. This enables closely timed work to be done on the effect of a second exposure occurring after a variable period; it is hoped, for example, that it will throw light on what has been called 'metacontrast' (inhibitory effect of post exposure[2]), Dodge's 'clearing-up process'[7] and the possible effect of eye movement on subsequent vision.

Preliminary Experimental Results

Taking as a starting-point the 'clearing-up process' experiments of Dodge[7], an investigation was undertaken into the conditions for clear vision of a pattern with very short exposures of consecutive fields. The experimental situation involved dark pre-exposure and post-exposure fields, two illuminated fields (called here 'first field' and 'second field') and a dark-interval between them.

The luminance of both fields, the areas of which were 6 in. × 6 in., was equal and constant (70 millilamberts). The first white field, on which a 2-in. black cross was inscribed in two circles 1 in. and 2 in. diameter, with the line 0·1 in. thick, was followed by a second clear field of varying duration. It was established that the perception of the pattern for exposures from 0·2 to approximately 6 msec. could be totally prevented by a second field of somewhat longer duration, and that for exposures from approximately 6 to 30–35 msec. this period was of shorter duration than the first field. (These are results for one subject—forty years old—over the whole range of experiments. The individual differences between subjects are considerable.) A pattern exposed for more than 40 msec. was always, at least in part, perceptible, although with long second fields the subjects saw it as a luminous cross, often followed by a positive after-image. A disturbance in visibility of the pattern over all the range of exposure was experienced when using second fields of shorter duration than those producing total inhibition.

Taking into consideration that the pattern field was easily perceptible when exposed without the second field, that the luminance of both fields was equal, and the time relations, it is not convenient to describe the disturbance in terms of glare.

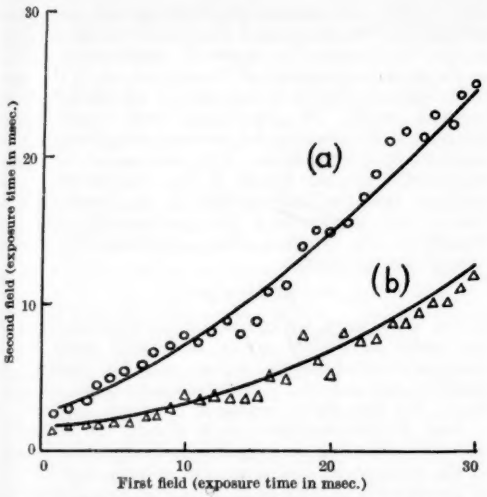

Fig. 3. Duration of a second field preventing or disturbing the visibility of the pattern in the first field: (*a*) no visibility; (*b*) bad visibility

The inhibitory or disturbing influence of the second field could be prevented by interposing a short dark-interval between the two fields. An interval of 65 msec. and more was necessary when a field of duration of 0·2 msec. was followed by a second field of duration more than 20 msec. For first fields of longer duration the dark-interval necessary for perception of the pattern was considerably shorter; for exposures more than 15 msec. a dark-interval of 20 msec. was usually adequate. The experimental results were cross-checked by keeping the exposure time of the first field and the dark-interval constant and increasing the duration of the second field until the pattern was no longer visible.

The reverse situation occurred when a clear first field was followed by a second field with a pattern. A clear first field of 3–4½ msec. duration produced a disturbance in perception of a pattern exposed for 1–5 msec., and one of 4½–7 msec. prevented clear vision in pattern exposures up to 14–15 msec. A pattern exposed for 15 msec. and more could not be rendered totally invisible to the subject by a first clear field of the same luminance, whatever its duration.

When the second field with the pattern was exposed for more than 6 msec. (but less than 15 msec.) and the duration of the first field was considerably increased (permitting some degree of adaptation), the subject reported a reappearance of the pattern. For example, with a pattern second field of 6 msec. he reported at 4 msec. duration of the first field a disturbance of vision, at 21 msec. a total disappearance of the pattern, at 240 msec. an appearance of a white cross on grey background, at 270 msec. the cross became blackish, and at 460 msec. the whole pattern was well cleared up. A pattern second field of 15 msec. duration was partly invisible with a 5 msec. clear first field. The biggest disturbance of vision was at 55 msec., but there was no total inhibition. At 73 msec. the subject reported improvement in vision, and at 103 msec. he reported a sharp, clear pattern. During the reappearance range he reported the arms of the cross 'coming back' earlier than the circles, and seeming very long and protruding beyond the circles.

As in the first experiment, a short dark-interval facilitated the perception of the pattern otherwise invisible. With very short first fields the subject reported the pattern as 'being there from the very beginning'. With long exposure of the first fields the pattern 'jumps' into the clear field.

The dark-interval was not always perceptible as an interval, and only in very few cases as 'dark'. There was a range of complete fusion of the first field and second field, a range of flicker and impression of doubleness with some apparent movement of the pattern, and a range of definite separation. The most important factor seems to be the duration of the first field in relation to the duration of the interval. The problem was investigated by Dunlap[4]; but his investigation technique was orientated towards 'singleness–doubleness' impression and towards perception of a dark field between moving illuminated ones, and not towards perception of interval, so that the problem is still with us.

Another problem arising from these experiments is that of the persistence of vision after stimulation has ceased. This can be expressed in terms of a dark-

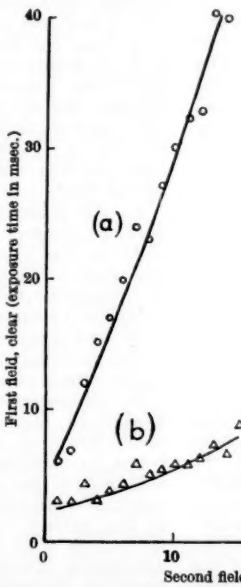

Fig. 4

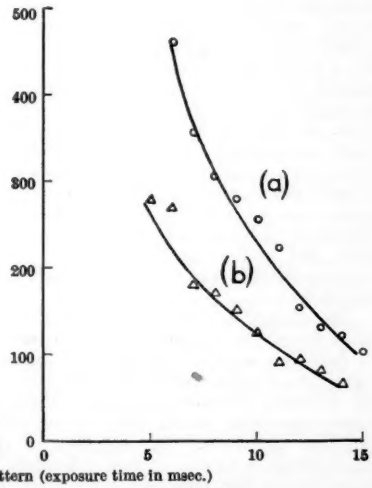

Fig. 5

Fig. 4. Duration of a clear first field preventing or disturbing the visibility of a pattern in the second field: (*a*) no visibility; (*b*) bad visibility

Fig. 5. Visibility of the pattern in the second field with long exposures of the first field (50–500 msec.): (*a*) all pattern clear; (*b*) part pattern discernible

interval which it survives to fuse with the second field (a cross on the first field inscribed in the circle on the second field). This is not claimed to be a time measurement, as the second field is itself an experimental variable influencing the first field.

Experiments upon metacontrast indicate that an explanation in terms of contour building process (similar to Werner's interpretation of his 1935 contour experiments[9]) cannot account for all the phenomena, since inhibition occurs with irregular and incongruent contours. Both tachistoscopic experiments and experiments with intermittent stimulation point to the importance of retinal distances, although Alpern's[10] statements are not fully acceptable.

The building of the apparatus and the conduct of the experiments were under the general supervision of Prof. G. Humphrey; the tachistoscope was designed and built by P. G. M. Dawe, and the great majority of the experiments performed by B. Mandell. The apparatus and research were carried out by the aid of grants from the Medical Research Council and the Watts Bequest. Acknowledgment is also made to the British Thomson-Houston Co., Ltd., Rugby, which manufactured the fluorescent tubes for this apparatus.

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MAGNETO-HYDRODYNAMICS

A DISCUSSION on magneto-hydrodynamics, organized by Sir Edward Bullard, was held in the rooms of the Royal Society on May 5. The proceedings were opened by Sir David Brunt, who took the chair for part of the discussion; he welcomed particularly the visitors from overseas, some of whom came from far afield. In his introduction Sir Edward Bullard said that the subject, which is concerned with the motion of a conducting fluid in a magnetic field, is not entirely new; but it was Prof. H. Alfvén, of Stockholm, who had rescued it from obscurity. The electromagnetic effects associated with such a motion are more conspicuous on a large scale, and the principal applications so far made are to astrophysical problems such as the theory of the sunspot field, the general solar magnetic field and stellar magnetic fields. There are also some applications in engineering, especially to pumps and flowmeters.

The subject is one which is understood in principle in so far as the relevant equations are known, being in fact the union of Maxwell's equations and the equations of motion and continuity of hydrodynamics. Sir Edward discussed at some length the terms in these equations which can be neglected in astrophysical problems. The solution of the equations is, however, a matter of real difficulty. Most of the solutions so far obtained have been derived from linearized equations, and he mentioned some examples of such solutions.

The next speaker, Prof. Alfvén, said that mathematical methods have been largely used for exploring the subject of magneto-hydrodynamics since its inception; but he pointed out that it is essential to explore the subject by means of experiments also in so far as certain aspects of the subject, as in the case of turbulence, cannot be ascertained by mathematical methods alone. He considered such experimental methods to be essential for a proper understanding of magneto-hydrodynamics. For excitation of magneto-hydrodynamic waves in the laboratory, it is essential that the field-strength B, the linear dimension of the apparatus l, the conductivity and the density of the liquid σ and ρ, respectively, should satisfy the inequality

$$Bl\sigma/\sqrt{\rho} \gg 1.$$

In the laboratory, we can attain fields of strength of the order of 10,000 gauss, and with such fields magneto-hydrodynamic waves can be excited in mercury and sodium. On the cosmical scale, l is very large, and the above condition is amply satisfied.

Prof. Alfvén then went on to discuss the nature of currents occurring in magneto-hydrodynamic effects in the ionosphere and solar atmosphere, and he was of the opinion that we have little evidence of currents extending over a large volume; these, he thought, tend rather to occur as filaments, and in support of this conclusion he quoted the auroral zone and the equatorial electrojects as examples. This effect is thought to be important in so far as it suggests the possibility that currents extending over large volumes are unstable.

Dr. B. Lehnert next described some beautiful experiments on magneto-hydrodynamics which he has lately carried out in Stockholm. In this, a shallow cylindrical bath contains mercury in which a brass ring is inserted, capable of rotating about the vertical axis of the cylinder. There is a fixed horizontal circular disk within the ring, and a fixed annular disk outside it, both concentric with the disk, resting half-way up the vessel. Dr. Lehnert showed that when the ring is rotated in a strong magnetic field the mercury over the ring is carried round as a rigid body, the outside fluid remaining at rest. Sir Edward Bullard interpreted this as an example of the theorem that, in a highly conducting liquid moving in a magnetic field, the magnetic lines of force are frozen in the fluid and tend to be carried by the fluid.

In the discussion that followed, Prof. S. Chandrasekhar showed some slides of some experiments made in the University of Chicago illustrating the inhibition of convection in mercury in the presence of a magnetic field. Prof. T. G. Cowling, referring to Alfvén's statement that cosmical currents tend to occur as filaments, said that he doubted the validity of this statement and that a filament current is more characteristic of an electrical discharge in gases.

Dr. D. Layzer next gave an account of a paper by himself, Dr. D. Menzel and Dr. M. Krook on torsional oscillations and solar magnetic fields. Dr. Layzer began by recalling the suggestion made by Cowling and Bullard that sunspot magnetic fields may be the result of a subsolar toroidal field which is convected to the surface. He suggested that, if the law of isorotation were violated at some initial instant, an alternating toroidal field would be produced by torsional oscillations of shells of magnetic lines of force, the sign of the field changing every half-cycle. Because of the low values of the kinematic and electromagnetic viscosities, such an oscillation could have existed throughout the past lifetime of the sun.

Dr. Layzer next considered how the submerged toroidal field is brought to the surface. The growth of a toroidal field at the base of the hydrogen convection zone gives rise to a hydrodynamic instability analogous to the instability of superposed fluids in a gravitational field when the upper fluid is heavier than the lower fluid. The tension of the magnetic lines of force plays a part analogous to that of surface tension, so that if one supposes that there is a sharp interface between the region containing a magnetic field and the overlying region in which no magnetic field is present, ripples of small amplitudes will tend to grow. Dr. Layzer suggested that this instability, rather than convection, is effective in convecting the subsolar toroidal field to the surface. The formation and subsequent dissipation of sunspot fields would draw energy mainly from the convection zone rather than from the primary oscillation. The equations governing the oscillations turn out to be linear in a first approximation, even if the amplitude of the oscillation is large. Hence, for a given magnetic shell the period is nearly independent of the amplitude. This point is a vital one in the theory which contemplates large-amplitude oscillations rather than small vibrations about an equilibrium state.

In the discussion that followed, Prof. Cowling pointed out that Walén has shown that a reasonable surface field would be produced by a variation in time of 1–2 per cent in mean angular velocity. Richardson's measurements at the surface do not show this. Hence, a substantially higher surface field-strength would be required.

Prof. V. C. A. Ferraro next discussed the generation of magneto-hydrodynamic waves in rare ionized gases and its bearing on galactic magnetic fields. Doubts have been expressed by several workers as to whether a rare ionized gas could behave as a perfect conductor on account of the very long free paths involved. Prof. Ferraro said that, if one neglects collision altogether, magneto-hydrodynamic waves may be excited in such a gas in the presence of a ('seed') magnetic field provided that the frequency of the waves is small compared with the gyromagnetic frequencies of the charges. The phase velocity of the waves is the same as that found by Alfvén; but the waves differ from magneto-hydrodynamic waves in liquids in that they are circularly polarized. In order to excite the waves, the linear dimensions of the gas must exceed the 'skin depth', that is, the depth to which an external alternating field would penetrate into the gas. As in the case of Alfvén waves, there is equipartition of mechanical and magnetic energy independently of the magnitude of the 'seed' magnetic field. Thus, provided a general magnetic field exists in the galaxy, however small, much larger fields may be generated, by magnification, as magneto-hydrodynamic waves through convection or turbulence. But it is essential that the 'seed' field should have an 'external' origin, and this assumption is difficult to substantiate.

Prof. Cowling considered the problem of magneto-hydrodynamic oscillations of a rotating fluid globe and, in particular, torsional oscillations. Steady rotation can only hold for isorotation. Torsional oscillations in the absence of rotation has been considered by Plumpton and Ferraro, who found a continuous spectrum for the normal modes of vibrations. This degeneracy might be removed by rotation; but in this case, Prof. Cowling pointed out, the variable magnetic field associated with the field cannot be purely azimuthal. On a rotating globe there must be, in addition to this field, a poloidal field also. Prof. Cowling referred to the equations of the problem and the boundary condition to be satisfied, and stated that these are sufficient to determine the solution. In the absence of rotation, the period of the oscillations is $2\pi/\sigma_0$, where

$$\sigma_0 = \frac{H}{a\sqrt{(4\pi\rho)}}$$

H being the magnetic field, ρ the density of the liquid and a the radius of the star. If the angular velocity of the globe Ω is greater than σ_0, the Coriolis forces will greatly affect the period: in this case the magnetic forces are balanced by the Coriolis forces, and we get

$$2\Omega\sigma \sim \sigma_0^2$$

where $2\pi/\sigma$ is the period of the oscillation; this would therefore exceed $2\pi/\sigma_0$. In the case of the sun, one finds that the differential angular velocity is destroyed in a time of the order of 10^7 years or more instead of 100 years. These results, however, do not apply to real stars, since the calculation is vitiated by the neglect of gravity. For, gravitational terms arise which largely prevent motion in meridian planes, and this means that the azimuthal Coriolis forces are no longer larger than the magnetic forces; thus, in spite of the fact that Coriolis forces are large, one can ignore them in considering torsional oscillation in actual stars. One may probably approximate to the periods of torsional oscillations using a form of Rayleigh's principle. In the discussion that followed, Prof. H. C. van de Hulst said that the solar cycle might well be a phenomenon too irregular to be classed as an oscillation.

Prof. Chandrasekhar opened the afternoon session with an account of an elementary theory of hydromagnetic turbulence which he has developed recently. He said that he has also developed a deductive theory along the lines of his recent theory of hydrodynamic turbulence; but there was no time to discuss it that afternoon. (It is understood that this will be published elsewhere.) The elementary part of the theory follows along the lines of Heisenberg's theory of ordinary isotropic turbulence. Prof. Chandrasekhar described in some detail the exchange of energy between the velocity field and the magnetic field; this, he showed, can be described in terms of an eddy resistivity and the spectrum of the random magnetic field, in a manner analogous to that of the inertial exchange of energy between the different Fourier components of the velocity field in terms of an eddy viscosity and the spectrum of the kinetic energy in Heisenberg's theory. The equations of stationary turbulence in this case lead to two essentially distinct solutions of the problem. Both solutions predict equipartition of kinetic and magnetic energy among the largest eddies present. For the smaller eddies, the ratio of the magnetic to the kinetic energy either tends to zero or to 2·6. Prof. Chandrasekhar then referred to the bearing of this theory on interstellar magnetic fields and especially the possibilities of distinguishing between Fermi's two pictures of galactic magnetic fields.

In the discussion that followed, Prof. van de Hulst asked whether, in Fermi's theory of the galactic magnetic field using gravitational arguments, the gravitational potential of the whole galaxy rather than that of a spiral arm should be considered. Furthermore, if the field is turbulent, can this be adopted as an explanation of starlight polarization? Dr. Layzer asked whether differential velocities are

not likely to be more effective in getting higher magnetic fields; and finally Prof. H. Bondi asked whether the method adopted by Prof. Chandrasekhar is sensitive to deviations from isotropy. Sir Edward Bullard commented that equipartition of energy for large eddies does not exist in the earth's core; there the force driving the material has to be taken into account.

Dr. A. Banos began by recalling the fundamental notions in the theory of magneto-hydrodynamic waves originally given by Alfvén. He referred to the work of Walén and to the laboratory experiments of Lundquist and Lehnert, but he said that no complete account of fundamental equations has yet been given without making simplifying assumptions. A start has been made by Dr. Banos in a recent paper (*Phys. Rev.*, **97**, 1435; 1955), and his contribution amounted to an account of this paper, which is a systematic study of the problem. He showed how the equations of the problem, namely the Eulerian equation of hydrodynamics and the Maxwellian equations, can be reduced to one fundamental equation in the fluid velocity. Dr. Banos then considered the linearized form of this equation and its solution for the case of incompressible fluids, and compressible fluids (which gives rise to magneto-acoustics) for the case of plane and cylindrical waves.

The next speaker, Dr. W. Marshall, discussed the structure of magneto-hydrodynamic shocks. He first recalled the structure of an ordinary shock-wave, and then considered theoretically the detailed structure of an infinite plane shock moving with uniform velocity into a region of stationary ionized gas in the presence of a magnetic field perpendicular to the line of flow. When the 'penetration depth' is smaller than a mean free path (as in the case of high electrical conductivity), the field is very nearly proportional to the density, and the shock point has a width of the order of a few free paths. In the case of a conducting gas of low conductivity, if the permanent magnetic field is less than a certain critical value, depending on the strength of the shock, we have a sharp shock in which only the velocity and temperature change is preceded by a wider region in which the velocity, temperature and field change slowly. In this case, we have the surprising result that the field changes take place ahead of the shock. When the permanent magnetic field exceeds the critical value, it prevents the rapid changes in velocity and temperature, and no sharp shock occurs. All quantities change slowly in a wide region.

Dr. R. Hide spoke on the generation of waves in a heavy electrically conducting fluid of variable density in the presence of a magnetic field. Considering the stable case in which the density decreases vertically with height, Dr. Hide said that the fluid always tends to return periodically to its equilibrium state when viscosity is zero. In this case the motion gives rise to 'gravity' waves propagated horizontally. In the case of a viscous fluid, only modes of disturbance characterized by an infinite range of wave-lengths generate damped gravity waves, other modes decaying aperiodically. If the fluid is conducting and there is a magnetic field present, the gravity waves are modified by electromagnetic waves. The linearized equations for any variation of density and kinematic viscosity are solved by a variational principle for the case when the electrical conductivity is constant and the impressed magnetic field uniform.

In the case of a continuously stratified fluid of finite depth, Dr. Hide was only able to examine in detail the case of infinite conductivity. The properties of the motions depended on two parameters G and Q defined by

$$G=\frac{g\beta d^4}{\pi^4\nu^2}, \quad Q=\frac{\mu H_0^2 d^2}{\pi^2\rho\nu^2}$$

where the density $\rho(z)$ is given by $\rho=\rho_1\exp(-\beta z)$; H_0 is the uniform magnetic field, ν the kinematic viscosity, d the depth of the liquid, g the acceleration of gravity, and μ the magnetic permeability. If k is the horizontal wave number of the motion, Dr. Hide finds that waves can be generated within a finite range of k if $G>27/16$ and $Q<1$, whereas when $Q<1/2$ and $G<27/6$ all modes are aperiodically damped, so that no waves are generated.

Dr. J. A. Shercliff spoke on some engineering applications of magneto-hydrodynamics. He said that engineers are interested in magneto-hydrodynamics chiefly on account of its use in electromagnetic pumps and flowmeters for liquid metals in nuclear power plants and elsewhere. The fluid motion in pumps is complex and difficult to analyse; the flowmeter problem is simpler, however, especially if turbulence is suppressed by the transverse magnetic field. The sensitivity of a flowmeter depends on the form of the velocity profile, and this may be disturbed by electromagnetic forces or upstream disturbances. As the fluid moves across the transverse magnetic field, currents are induced which affect the velocity profile and sensitivity.

Dr. Shercliff then considered the equations of the problem; these involve two parameters, the Reynolds number and a number depending on the magnetic field. If the transverse magnetic field is of sufficient extent in the direction of flow, there is a further distortion of the profile, and in a circular non-conducting tube the sensitivity falls by some 7 per cent if the velocity profile is fully distorted from axial symmetry by electromagnetic forces. The theoretical results obtained have been verified experimentally. Dr. Shercliff also considered the effect of orifices in the surface of the tube, and said that the sensitivity can be large or low or even negative at various points of the surface of the tube.

The last speaker, Dr. W. B. Thompson, considered the acceleration of cosmic-ray particles by magneto-hydrodynamic waves. Dr. Thompson first reviewed Fermi's theory of the origin of cosmic rays put forward in 1949 and recalled that Fermi had derived the exponent in the energy law as the ratio of two times—an acceleration time t_1 and a mean life of energetic particles t_2. In this theory the particles gain energy through elastic collisions with a moving magnetized cloud of gas. In a form of the theory due to Morrison, Olbert and Rossi, t_2 represents the time needed for an energetic particle to diffuse out of the galaxy, and the theory seems able to provide an explanation of most of the observed features of the part of the cosmic-ray flux of greatest energy. However, on this theory t_1 is of the order of 10^8 years, which is at least an order of magnitude too large. This led Fermi to attempt a more efficient accelerating mechanism.

Dr. Thompson then directed attention to a mechanism, so far overlooked, indicated by recent views on the galactic magnetic field. If one supposes, with Chandrasekhar and Fermi, that there is a general field of the order of 10^{-6} gauss in a spiral arm and if Fermi's magnetized clouds are also present, these might act as scattering centres enabling cosmic-ray particles to be accelerated to high energies by the

electric fields associated with the magneto-hydrodynamic wave. On the basis of this mode, an approximate calculation of the rate at which relativistic particles acquire energy leads to a time t_1 such that

$$\frac{1}{t_1} \sim \frac{1}{x}\frac{v}{c}\left(\frac{\delta H}{H}\right)^2$$

where v is the velocity of the magneto-hydrodynamic wave of wave-length λ, and δH is the amplitude of the wave. By taking v to be of the order of 30 km./sec. (the value adopted by Fermi), λ of the order of 10 light-years, $\delta H/H \sim \frac{1}{4}$, one finds t_1 to be of the order of 10^6 years, a value small enough to give agreement between astrophysical and cosmic-ray data.

V. C. A. Ferraro

OBITUARIES

Dr. C. S. Orwin

Deep regret will be widely felt for the death of Charles Stuart Orwin at his home at Blewbury, Berkshire, which occurred on June 30. He was born at Warnham in Sussex in 1876 and was educated first at Dulwich College, then at Wye College, which he entered in 1895, its second year of establishment as an agricultural institution. He was fortunate both in his fellow students and in his teachers: the subject was new and the principal, A. D. Hall, had the gift of attracting an able body of enthusiastic pioneers. Orwin thoroughly absorbed the spirit of the place and throughout his life held it in great affection; in particular, he had great admiration for Hall, who in turn thought very highly of him.

Orwin early became interested in the organization and development of agriculture, and on leaving Wye in 1897 he worked with an estate agent in Tonbridge and then for a short time in the City of London; he returned to Wye in 1903 as lecturer in estate management. He did not, however, remain long. Mr. Christopher Turnor, who had inherited the family estates in Lincolnshire, wished to develop them on sound lines, and in 1906 he invited Orwin to take over the management; this he did with satisfaction to all concerned.

Meanwhile, A. D. Hall was insisting that agriculture as a technical subject could not be taught apart from quantitative knowledge about the various operations; he was surprised at the vague ideas on the subject of costs and times required that were held by the ordinary college lecturers. Orwin took up the subject with enthusiasm, developed systems of bookkeeping which farmers could use, and built up a body of carefully ascertained knowledge on farming operations and their results, on which a new subject, agricultural economics, could be built up. Hall by this time was the Permanent Development Commissioner and had established an Institute for Agricultural Economics at Oxford: Orwin was put in charge and, with the aid of a succession of able young colleagues, was able to produce a series of valuable reports, first on a county basis, afterwards on more general lines. He was appointed assessor to the Agricultural Tribunal set up in 1922 to study the agricultural crisis of those days, and its report, issued in 1924, for the drawing up of which he was largely responsible, is justly regarded as one of the best on the state of British agriculture.

He was much interested in the history of agriculture, and was fortunate in having an able helper in the gifted wife of his second marriage. Together they produced in 1939 "The Open Fields", based on a study of the system still surviving at Laxton; this is now the standard treatise on the subject. His other works included an account of John Knight's reclamations at Exmoor in the early nineteenth century, a subject in which interest has been renewed by Earl Fortescue's recent reclamations, and a very readable short "History of English Farming" (1949). He adopted Hall's revolutionary view that the Government should acquire all the agricultural land of the country and redistribute it in larger units; he dealt with this in "Speed the Plough". His method of investigation is well seen in "Country Planning, a Study of Rural Problems" (1944), the work of a team under his direction.

Orwin's wide knowledge, sound judgment and deep sympathy with the small farmer and the worker made him a very acceptable member of the Agricultural Wages Board and of numerous other committees of inquiry, while Balliol College very shrewdly secured his help by making him estates bursar. He had his share of honours: Oxford conferred upon him the degree of D.Litt., Balliol made him an honorary Fellow and Wye College also elected him to a fellowship; but he lives in the memory of those who knew him as a friend ever ready to help and who steadfastly maintained the best traditions of the English country gentleman.

E. John Russell

Prof. F. J. Lewis

The death of Francis John Lewis on May 24 at the age of eighty marks the passing of one of the very few links left with the grand old tradition of British botany led by Bower, Oliver, Gwynne-Vaughan and others. Unlike most of his contemporaries, however, Prof. Lewis spent most of his botanical career overseas.

He was born in London in 1875 and received his early training at the Imperial College of Science and Technology, London, and at the University of Liverpool, from which he received the degrees of M.Sc. in 1908 and D.Sc. in 1912. He was appointed demonstrator in the University of Liverpool and held this post until 1905 and then became lecturer in geographical botany until 1912. During that time he did a great deal towards establishing the branch of geographical botany in undergraduate courses. In 1912 he was appointed professor of botany in the University of Alberta, Edmonton, Canada. There he worked and developed that department for twenty-three years until he resigned in 1935.

Lewis was an exceptionally active man both physically and mentally, and this meant that he could scarcely be expected to live in retirement. So in 1935 he exchanged to a very different environment—that of Egypt, where he was appointed professor of botany in the Fouad I University of Cairo in succession to F. W. Oliver. His headquarters were for some years in the old Zafaraan Palace at Abassia. In spite of the hampering episodes of wartime in the Middle East, he developed a small laboratory on the Suez Road where he investigated the phenomena of dew formation in the desert and studied the permeability of leaf tissues. He also took a leading part in the transferring of the Botany Department to the fine new building at Giza. There he organized the spacious laboratories and built up an excellent staff of Egyptian botanists. From the

new laboratories, the botanical staff were able to work in much closer co-operation with the Egyptian Ministry of Agriculture Laboratories, the Cotton Research Laboratories and others which were nearby.

Although Prof. Lewis retired from Cairo in 1946 when he was seventy-one years of age and returned to Great Britain, he was still as active as a man half his age. He therefore accepted for one year the appointment of visiting lecturer in plant physiology in the Royal Holloway College (University of London). His knowledge of physiology and ecology stood him in good stead, not only there, but also in other activities such as that of an advisory editor to the new edition of "Chambers's Encyclopædia".

In 1905 Lewis was awarded the Cuthbert Peek Fund of the Royal Geographical Society and in 1910 he was awarded the Neill Gold Medal of the Royal Society of Edinburgh, of which he was a Fellow. He was also Fellow of the Royal Society of Canada and of the Linnean Society. His work in connexion with "Chambers's Encyclopædia" instilled in him an enthusiasm for publications, with the result that right up to the time of his death he took an active part in forming a liaison between the publishing firm of Macmillan and Co., and British universities, visiting them all in turn.

W. Lawrence Balls
L. J. F. Brimble

NEWS and VIEWS

The Indian Botanic Garden : Dr. K. P. Biswas

Dr. K. P. Biswas retired on August 1 from his post as superintendent of the Indian Botanic Garden. He was appointed curator of the Herbarium of the Botanic Garden in 1927, and superintendent in 1938 when Mr. C. C. Calder retired. Dr. Biswas specialized in Algæ and systematic botany. He was granted study leave in Europe during 1937–38 and worked at Dr. F. E. Fritsch's laboratory at Queen Mary College, the Edinburgh Botanic Gardens and at the Herbarium of the Royal Botanic Gardens, Kew. During this time he was awarded the D.Sc. degree of the University of Edinburgh. He has published a number of papers in the *Records of the Botanical Survey of India*, of which he was the editor, and in several local and foreign journals—*Kew Bulletin*, *Hooker's Icones Plantarum*, etc. He has also published some important botanical treatises, among which is "Bharatiya Banaushadhi" in Bengali (3 vols.)—a joint publication for which he was awarded the Rabindra Memorial Prize in Science in 1951–52. A book on "Medicinal Plants of Sikkim Himalaya" is now passing through the press as a result of his detailed study of the Flora of Sikkim Himalaya. Improvements of the Garden and its amenities were effected during the past twenty-eight years of his service by introducing and acclimatizing many plants both in the Lloyd Botanic Garden, Darjeeling, and the Indian Botanic Garden, Calcutta. The Lloyd Botanic Garden, Darjeeling, was re-organized into a Phyto-Geographical Garden by arranging the plants according to their proper classified order. Dr. Biswas takes keen interest in the cultivation of medicinal plants in India. It was at his initiative that the Government of West Bengal started the cultivation of plants yielding some important drugs in the Eastern Himalaya (Rungo) under the joint auspices of the Medicinal Plants Committee of the West Bengal and of the Medicinal Plants Scheme of the Indian Council of Agricultural Research. During his regime extensive collections were added to the Botanic Garden Herbarium from South Burma, Naga Hills, Manipur (Assam), Sikkim, Orissa, Bihar (Santhal Parganas), etc. In India he has received many honours, such as the Elliot Medal and Bruhl Medal of the Asiatic Society of Bengal. He was president of the Botany Section of the Indian Science Congress in 1943, president of the Botanical Society of India in 1952 and president of the Botanical Society of Bengal during 1948–50. He is honorary lecturer in botany in the University of Calcutta.

Dr. D. Chatterjee

Dr. D. Chatterjee, systematic botanist at the Indian Agricultural Research Institute, New Delhi, has been appointed to succeed Dr. Biswas. Dr. Chatterjee was born at Chinsurah, near Calcutta, on April 2, 1911. He studied botany at the Presidency College, Calcutta, where he specialized in systematic botany. Later, he went to the University of Edinburgh and was awarded the Ph.D. degree of that University in 1939. His work in Edinburgh consisted of a critical study of the distribution of the Himalayan and Indian flora. On his return to India in 1939, Dr. Chatterjee worked for some time at the Indian Botanic Garden, Calcutta, and in 1940 went to Burma as a lecturer in botany in the Agricultural College, Mandalay. The War in Burma, however, did not allow him to stay there long and he returned to India in April 1942. He worked again at the Indian Botanic Garden, Calcutta, for nearly a year, and later, in July 1943, he was appointed a lecturer in botany at the Cotton College, Gauhati, Assam. He again went to Britain early in 1946 and joined the Royal Botanic Gardens, Kew, London, as botanist for India, from which he published some valuable papers dealing with new discoveries of several plants and on nomenclature of plants. In 1948, while working at Kew, he was deputed by the Government of India to attend the Symposium on Botanical Nomenclature held at Utrecht, Holland. Dr. Chatterjee returned to India from Kew in April 1949 and was appointed systematic botanist in the Indian Agricultural Research Institute, New Delhi, in June 1949. While there he published papers dealing with the origin of cultivated rice and other cultivated plants. He has also taken up the classification of cultivated wheats of India. In appreciation of his work on Indian flora, Dr. Chatterjee was made a vice-president of the International Botanical Congress held in Paris in 1954, and was awarded a Special Centenary Medal of the Société Botanique de France. He was also awarded the Brühl Memorial Medal of the Asiatic Society of Bengal this year (1955), for meritorious work done in the field of botanical research during the past five years. Dr. Chatterjee has travelled widely and has worked in several European herbaria and botanical gardens. In view of his long experience in taxonomy and nomenclature, we feel confident that Dr. Chatterjee will prove a very able superintendent of the famous Botanic Garden at Sibpur, Calcutta.

Economic Factors in World Peace

In his Alex Wood Memorial Lecture, "The Reconciling Spirit and the Economic Order", delivered in Glasgow on February 19, and which has now been published (pp. 17. London: Fellowship of Reconciliation, 1955; 1*s.* 6*d.*), Prof. C. F. Carter analyses first the several arguments that the causes of war are primarily economic. He believes that economic factors have played only a subsidiary part in the great conflicts of this century, that we are justified in thinking that we are achieving more, and not less, willingness to consider the interests of others and that pacifists have drawn too sharp a distinction between police action and war. Economic wrong, waste and injustice still have to find their remedy; but, as Prof. Carter points out, we cannot afford to do without the great efficiency of large-scale factory production and, while the capitalist system can show examples of ruthless or dishonest profit-making, it can also show many of disinterested public service. Any other way of running our economic affairs would equally depend on much the same human beings, nor is there a simple choice between a system based on competition and one based on co-operation; both exist in any economic system. Inequality and competition between individuals result from our need for a discipline to help us give of our best in production, and such a discipline is not necessarily a bad thing. The conflict between management and labour is not necessarily to be removed by a change to public ownership but by better techniques of management —a more imaginative understanding of the other man's work and aspirations. While, therefore, we should not ascribe to a particular economic system difficulties which would be inherent in any economic system and should distrust the simple solution, Prof. Carter pleads for greater efforts to understand the position of the other man, to see the good in that and the evil in our own, and to be solid and sensible in our proposals for change. Anything we can do to increase personal knowledge about those with whom we are in an economic relationship can be a way of lessening conflict.

Mount Everest Foundation

A Mount Everest Foundation for the support of scientific work in mountain regions has recently been set up by the Royal Geographical Society and the Alpine Club with funds acquired from the proceeds of the books, film, lectures and other activities which followed the successful Everest Expedition of 1953, sponsored by the two bodies. Within the broad object of supporting the exploration of mountain regions, the Foundation will particularly aid mountaineering expeditions exploring, to some extent at least, little-known or unknown territory, but not necessarily engaged in a particular branch of scientific research; but provision is also made, more specifically, for the support of scientific investigations in mountain country, not necessarily involving special mountaineering technique, or new exploration in a geographical sense. In this scientific field, grants may be made for research into geography, topography, geology, ethnology, meteorology, botany, zoology, entomology, glaciology, and allied studies, either in, or concerned with, mountain regions; physiological studies dealing with the effects of altitude upon the human organism, and the means of countering such effects, are also among the objects of the Foundation. Those seeking grants should write for application forms to the Honorary Secretary, Mount Everest Foundation, c/o Alpine Club, 74 South Audley Street, London, W.1. The forms should reach the Foundation not later than February 1, April 1 and October 1 each year, for consideration in April, June and December, respectively.

New Nature Reserves in Britain

The Nature Conservancy on July 28 announced the establishment of three new nature reserves. The first of these, the Wychwood Forest Nature Reserve, covers about 647 acres of mixed woodland, about seven miles west of Woodstock. The mixed fauna and ground flora are rich, and it is intended that the reserve shall be a permanent forest, regenerating naturally and consisting of indigenous species of hardwoods on a long rotation. The reserve will be used for scientific research and will not be open to the public. The Tring Reservoirs Nature Reserve covers an area of 50 acres of the banks only of the four reservoirs, Wilstone, Marsworth, Little Tring and Startopsend, which when full have a combined water area of more than 200 acres. The marshy ground provides a habitat for plants such as the round-fruited rush (*Juncus compressus*), the orange foxtail (*Alopecurus aequalis*) and the broad-leaved ragwort (*Senecio fluviatilis*), which are rare in Britain; but the reservoirs are best known to naturalists as a bird sanctuary, and in 1938 were the first recorded site in Britain for the nesting of the little ringed plover. The nesting species include shoveller, teal, pochard and tufted duck, little and great crested grebe, reed warbler and sedge warbler. Permits will be necessary for those wishing to undertake research, collect specimens, or to visit parts of the reserve away from the footpaths. The Hales Wood Nature Reserve covers only twenty acres about two and a half miles from Saffron Walden, and is one of the best known examples in Britain of oak–ash woodland on chalky boulder clay where the true oxlip (*Primula elatior*) has replaced the primrose in the herb layer. The shrub layer consists mainly of hazel, with occasional maple, blackthorn, dogwood and the large guelder rose; as the wood must be kept undisturbed, access permits can be granted only in very limited numbers and for special reasons.

Department of Scientific and Industrial Research

In a written answer in the House of Commons on July 21, Mr. J. R. Bevins, Parliamentary Secretary to the Ministry of Works, as representing the Lord President of the Council, gave the names of the members of the committee which is investigating the work of the Department of Scientific and Industrial Research as follows: Sir Harry Jephcott (chairman), chairman and managing director, Glaxo Laboratories, Ltd.; Mr. C. H. Andrew, deputy secretary, Board of Trade; Sir Hugh Beaver, managing director, Arthur Guinness, Son and Co., Ltd.; Mr. E. W. Playfair, third secretary, H.M. Treasury; Sir Alexander Todd, professor of chemistry, University of Cambridge.

Recent Lunar Research

A paper by Dr. H. Percy Wilkins which appears in the *Journal of the British Interplanetary Society* (**13, No. 6**; November 1954) is the first of a series of papers which are to appear dealing mainly with changes in lunar topography. Dr. Wilkins returned recently from a tour of the United States where, as he describes it, "with traditional courtesy and hospitality the giant American telescopes were freely placed at my disposal . . .". The instruments

that he used were the 60-in reflector at Mt. Wilson Observatory and the 26-in. refractor at the Naval Observatory, Washington. An account is given of his observations on cracks and clefts, the first object dealt with being the crater of Vendelinus. In 1891, T. Gwyn Elger, the first director of the Lunar Section, British Astronomical Association, observing this crater with his 8½-in. Calver reflector, saw a cleft or crack running north from a small crater on the northern part of the interior, and Elger recorded this cleft later, additional confirmation being obtained by Dr. W. H. Maw's observations with his 6-in. refractor. Wilkins and other experienced observers failed to find a trace of it, and the remarkable thing is that not only did the 60-in. telescope reveal no cleft, but where it once appeared Wilkins saw elevations. Perhaps more remarkable still is the fact that though the cleft had vanished, two new ones had opened up, one on each side of its former position. An examination of Mare Humorum with the Washington 26-in. refractor showed that the border of this plain, which had been known to be extensively cracked, was much more cracked than had been previously suspected. Five clefts seem to be new and one marking shown by the older observers as a ridge is now a cleft. These are only two instances, supported by a considerable body of evidence, and suggest that cracks are still being formed.

Excavations at Kirkstall Abbey, near Leeds

The Thoresby Society has been excavating for a number of years at Kirkstall Abbey, near Leeds, and the fifth report of the Society, covering 1954 (pp. 16+2 plates; from the Society, Leeds; 1955; 1*s.*), describes an interesting find of a large earthenware crucible. The crucible is 17¼ in. high and 17¾ in. in diameter at the top, decreasing to 11½ in. at the base, and was used for refining copper or bronze. Metallurgical methods and processes, whether used in the Bronze Age or in later medieval times, are always of interest, and the new find adds considerably to our knowledge of how the folk of this latter period worked. A general account of metallurgical processes is also given, and this will be welcomed by students of many different periods who have not had any training in chemical studies.

A Museums Calendar for British Museums and Art Galleries

For many years the museums, art galleries and cognate institutions in Great Britain have suffered from a lack of current and reliable information concerning themselves and allied institutions. At one time and another directories have been issued, but these are costly compendiums and are soon out of date. The Museums Association has recently issued an excellent "Museums Calendar" which contains an almanac for 1955, various details of the Association, including notes on its past history, regulations for both its diploma and technical certificate, a complete list of institutional and personal members, and a list of all the museum and art galleries in Great Britain. Details of the present policy of the United Kingdom Carnegie Trustees towards museums are given, as well as particulars, with a useful map, of the regional federations. For the present issue it was only possible to collect information regarding certain overseas museums and art galleries, but in subsequent annual editions, to be issued in January, this feature will be greatly extended. Such a publication is indispensable for those working in, or associated in any way with, British museums and art galleries. In stiff paper covers, it is published at the reasonable price of 5*s.* and can be obtained from the Museums Association, 33 Fitzroy Street, London, W.1.

Distribution Maps of Scandinavian Species of *Hieracium*

During the last few years of his life, Prof. Gunnar Samuelsson was engaged on a compilation of some of the main features of the plant geography of the Scandinavian *Hieracium* flora. To this end he had prepared distribution maps of more than a hundred species. At the time of his death in 1944 these maps were in a more-or-less complete state; but they had not been worked up or commented on in any way. This has now been done by Erik Almquist, the work being available as a publication of the *Kungl. Svenska Vetenskapsakad. Handl.* (Fjärde Serien, **5**, No. 3; 1954). This monograph includes 123 maps and a short foreword and index. According to the editor, "Samuelsson's main intention seems to have been to bring to light a number of different distributive types, and to show, at the same time, how far we have come in our knowledge of the occurrence of the more important species". The commentary in the foreword on the distribution of different species and groups is brief; but a number of interesting points are made. In particular, the view is expressed that, although most species of *Hieracium* are in various ways favoured by cultivation, the maps nevertheless afford a fair indication of their natural distribution, certainly of the species of at least some sections of the genus. It is held that spreading of a synanthropic kind over large distances is unusual. Species of other sections, on the other hand, are more-or-less entirely associated with localities under cultivation; but the bulk of the area's species "undoubtedly consists of endemic small species of varying age, having mostly emerged in post-glacial time".

Speciation and Variation in Asexual Fungi

In a monograph under this title, published under the editorship of R. W. Miner, as Vol. 60, pp. 1–182 (1954), of the *Annals of the New York Academy of Science*, readers will find a rich collection of well-illustrated information on this important botanical topic. As Dr. K. B. Raper says in the introduction: "I do not believe that we are dealing with problems basically different from those faced by an investigator concerned with the taxonomy of micro-organisms. In the so-called asexual fungi, however, these problems become particularly acute. The very fact that these organisms reproduce themselves so successfully without the intervention of sexuality at once precludes from consideration a developmental phase with attendant characteristics and structures which, if present, would normally provide the most stable features possible. In the absence of such features, we must somehow get along with what is left". The individual contributions cover a wide range of mycological themes, such as interrelationships of speciation, type preservation, and nomenclature in bacteria; variation and speciation in the genus *Fusarium*; the evolution of species concepts in *Aspergillus* and *Penicillium*; spontaneous and induced variation in selected stocks of the *Penicillium chrysogenum* series; experimental control of morphogenesis in micro-organisms; natural and cultural variation in entomogenous Fungi Imperfecti; types of variation in Actinomycetes; variation and

criteria of speciation in the genus *Streptomyces*; 'Ektachrome' transparencies as aids in Actinomycete classification; induced mutation and strain selection in some industrially important micro-organisms; morphological studies in the genus *Nocardia*.

Statistics of Petroleum Products in Britain

STATISTICS recently issued by the Petroleum Information Bureau on behalf of the Petroleum Industry Advisory Committee reveal that in 1954, for the first time, the United Kingdom used more than twenty million tons of petroleum products (excluding bunkers for ships engaged in foreign trade). Actual total inland consumption was 21,038,511 tons—more than two million tons increase on the corresponding figure for 1953. Of this total, nearly six million tons represents motor spirit (including motor benzole); 1·3 million tons burning and vaporizing oils; 1·4 million tons derv fuel; 6·3 million tons gas, diesel and fuel oils. Consumption of all other petroleum products showed substantial increases over corresponding figures for 1953. Of indigenous materials made available for distribution in the United Kingdom by the industry, motor spirit by low-temperature carbonization and also refined benzole showed increases compared with 1953.

Library of the University of Leeds: Report for 1953–54

THE annual report of the Librarian of the University of Leeds for the session 1953–54 (pp. 11; Leeds, 1954) records holdings of books and pamphlets totalling 540,770 on June 30, 1954, accessions during the year totalling 13,347 volumes, 2,421 pamphlets and 25,086 periodical parts. Of these, 6,503 volumes and 1,684 pamphlets were presented, while many books and periodicals were obtained by systematic exchange, particularly with the Biblioteca Apostolica Vaticana, the British Museum, the Library of Congress, Societas Entomologica Fennica and the Universities of Berne, Helsinki, Marburg, Münster and Zurich. The second instalment of the new stack and mezzanine floor has given complete satisfaction both on practical and æsthetic grounds, and it is hoped that the scheme will be completed in the near future by the addition of the two surrounding portions which will bring the new floor to the outer perimeter and make provision for research readers. There was an increase of 5 per cent in cataloguing done during the year; but the position of the Medical Library further deteriorated, and there is now insufficient space for text-books and monographs and the commonly used periodicals. Plans have been made for a small extension of the building which it is hoped will have been undertaken early this year.

Chemistry and Biology of Phospholipids: Symposium in London, Ontario

THE Biochemistry Division of the Chemical Institute of Canada is sponsoring a symposium on phospholipids, to be held in the University of Western Ontario, London, during October 12–13, immediately preceding the meeting of the Canadian Physiological Society. The symposium will consist of two sessions on the following topics: chemistry of phospholipids (chairman, A. M. Wynne, University of Toronto), at which phosphoglycerides, inositol phospholipids and sphingolipids will be discussed; and metabolism and function of phospholipids (chairman, W. R. Bloor, University of Rochester, New York), at which their biological synthesis, metabolism *in vitro*, and function will be discussed. Members of the Canadian Physiological Society and others interested may attend the symposium. There will be a registration fee of one dollar. Further information can be obtained from Dr. R. J. Rossiter, Department of Biochemistry, University of Western Ontario, London, Ontario.

Announcements

SIR ARNOLD HALL, director of the Royal Aircraft Establishment, Farnborough, since 1951 (see *Nature*, 168, 19; 1951), is retiring and will join the Hawker Siddeley Group as technical director. He will be succeeded at Farnborough by Mr. G. W. H. Gardner, director-general of technical development (air) at the Ministry of Supply.

THE Council of the Physical Society has made the following special awards for 1956: *Guthrie Lecture*, Sir Francis Simon; *Rutherford Lecture*, Prof. P. I. Dee; *Duddell Medallist*, Prof. J. G. Gaunt; *Charles Vernon Boys Prize*, Dr. G. D. Rochester and Dr. C. C. Butler.

THE Executive Council of the Commonwealth Agricultural Bureaux has elected Mr. J. E. C. Coventry, representing the Federation of Rhodesia and Nyasaland, as its chairman, in succession to Mr. W. F. C. Morton, who represented the Union of South Africa. Mr. A. I. Perera, representing Ceylon, has succeeded Mr. Coventry as vice-chairman.

DR. HELEN MARGUERITE MUIR-WOOD, principal scientific officer in the Department of Geology, British Museum (Natural History), has been appointed deputy keeper in that Department. Dr. Muir-Wood is a graduate of the University of London (Bedford College and University College) and went to the British Museum (Natural History) in 1922. She was given charge of the Brachiopoda, on which group she has published a number of monographs and papers.

DR. T. A. M. NASH, deputy director of the West African Institute for Trypanosomiasis Research, Kaduna, Northern Nigeria, has been appointed director of the Institute, the appointment dating from October 17, 1954, when Colonel H. W. Mulligan retired. Dr. Nash, who is well known for his work on the ecology and control of tsetse flies, has been connected with the Institute as chief entomologist and deputy director since its inception in 1948; he has been engaged in tsetse work since his first appointment to Tanganyika Territory in 1927.

IT has been decided to change the name of the Royal Sanitary Institute; it will be known in future as the Royal Society for the Promotion of Health.

THE Chemical Research Laboratory (Department of Scientific and Industrial Research), Teddington, Middlesex, is having open days during September 27–29. Applications for invitations should be sent to the Director not later than August 31; those already on the mailing list need not re-apply.

THE Institution of Chemical Engineers and the Society of Instrument Technology have arranged a joint conference on "Automatic Control in the Process Industries", to be held at the Caxton Hall, London, S.W.1, on October 4. Further particulars can be obtained from the General Secretary, Institution of Chemical Engineers, 56 Victoria Street, London, S.W.1.

PROBLEMS OF INTERNATIONAL CONCERN IN THE BIOLOGICAL SCIENCES

DURING the Twelfth General Assembly of the International Union of Biological Sciences, held in Rome in the rooms of the Consiglio Nazionale delle Ricerche during April 12–16, a symposium was held on "Problems of International Concern in the Biological Sciences" with the aim of discussing some possible lines for the future work of the Union. The symposium was centred around seven major topics, and the discussion of each was introduced by a panel of three. In each panel one of the three acted as the chairman of the discussion.

For the first topic, "Standards, Units, Symbols and Terms", A. Frey-Wyssling (Botanisches Institut, Zurich) was chairman, and J. H. Burn (Department of Pharmacology, Oxford) and E. Hadorn (Zoologisches Institut, Zurich) were the main speakers. It was recommended that the Union should urge the universal adoption of the decimal system for international scientific publications: editors of international periodicals should be requested to convert all units into the decimal system if the authors had not already done so. A more general resolution aiming at promoting the unification of standards, units, symbols and terms in the field of biology was adopted by the General Assembly. Dr. Burn discussed the successive steps in the co-ordination of international standards for substances demanding biological assay. The matter is now regulated by an organization established under the auspices of the United Nations World Health Organization, which is working well. Dr. Hadorn's speech was especially concerned with the work of the Committee on Genetical Nomenclature and Symbols. It is planned to have a conference on this topic immediately before the next International Congress of Genetics, which is to be held in Montreal during 1958.

The second topic dealt with the "Organization and Support of Research", with R. E. Cleland (Botanical Institute, Bloomington, Ind.) as chairman, and C. F. A. Pantin (Zoological Laboratory, Cambridge) and B. Rajewsky (Max-Planck-Institut, Frankfurt-am-Main) as main speakers. The matter was thoroughly discussed, and finally it was suggested that the International Union of Biological Sciences should attempt four things: to persuade countries to undertake co-operative solutions of problems which transcend national boundaries; to make pronouncements on matters of world-wide scientific concern where the welfare of science is threatened by considerations involving the interests of individual nations; to organize programmes of research which cannot be organized by individual nations; to devote some of its time to the consideration of future trends in biology, and of how certain major problems of biologists, such as publishing, can be solved in the future (to this end the Union might sponsor symposia from time to time on such topics, either at the time of the General Assembly, or independently).

The third topic, "Teaching and Training", was introduced by P. Weiss (Rockefeller Institute, New York). The invited speakers were Chr. P. Raven (Zoologisches Laboratorium, Utrecht) and W. Ankel (Zoologisches Institut, Giessen). The discussion centred around the dilemma, clearly pointed out by Weiss, that, on one hand, biology has developed from many independent branches which are gradually discovering their common principles, thus calling for a deliberate integration; and, on the other, that the increasing volume of biological research and the spectacular advances in certain lines are fostering a dispersive tendency toward further fragmentation. The rate of progress in the biological sciences will depend to a great extent on the rate at which biological teaching can be made to cope with these conflicting trends and adapt itself to the changing situation. Students should be prepared for the biology of the future rather than educated in that of the past.

The subject of the fourth topic was "Publications", and for this M. J. Sirks (Genetisch Institut, Haren) was chairman, with B. Glass (Department of Biology, Baltimore, Md.) and P. Rosbaud (Pergamon Press, Ltd., London) as panel members. The international support of periodicals should go first to the abstracting and indexing periodicals; second, to review periodicals and book series; third, to handbooks of data, indexes, lists of materials and workers, dictionaries of symbols, etc.; and lastly, to monographs of a costly and truly international scope.

In view of the magnitude of the literature to be surveyed, the abstracting and indexing journals must begin to co-operate and co-ordinate their efforts. It was recommended that they apply for admission to the Abstracting Board of the International Council of Scientific Unions and that they work out a co-operative plan. Since both general and specialized abstracting periodicals are for the present necessary, the latter should provide the former with a selected coverage of special fields, and each of the former should undertake to cover completely a nucleus of journals not dealt with by the other general abstracting services. Review periodicals and book series should be subsidized so far as possible in order to reduce their present high cost to users throughout the world. Co-ordination should be developed to prevent simultaneous reviews of the same subject in different places.

The recommendations to the Executive Committee of the International Union of Biological Sciences with regard to the fifth topic of the symposium, "Supplies and Depositories" (Dr. L. Harrison Matthews (Zoological Society, London) chairman, with A. van Straelen (Museum of Natural History, Brussels) and J. Westerdijk (Centraalbureau voor Schimmelcultures, Baarn) as panel members), were threefold. *Living materials.* The appointment of a small international committee to study the problems of the supply of laboratory animals, the cataloguing of users and of sources of supplies, the definition of standards and related matters on an international scale; representatives of the Division of Botany and of the Sections of Microbiology and Genetics should be included in the committee to advise upon the matters relating to their subjects. *Museum collections.* While the documentation of botanical type specimens

appears to be satisfactorily in progress, the same cannot be said for zoological type specimens. It might be useful to ask a small panel of zoologists to draw up recommendations for the preservation, collection and cataloguing of zoological type specimens, the distribution of co-types and para-types, and the safeguarding of the type specimens in times of international emergency. *International expeditions.* Unesco should be advised when international expeditions are under consideration, both for the selection of personnel and for the distribution of specimens collected.

The chairman for the sixth topic, "International Congresses and Conferences", was J. Runnström (Wenner Grens Institutet, Stockholm), and the invited speakers were Sir Gavin de Beer (British Museum (Natural History), London) and P. Chouard (Conservatoire National des Arts et Métiers, Paris). The main conclusions of the discussion of this very important topic were as follows. The large international congresses should not be suppressed; their need is still very great in the biological sciences to avoid the danger of over-specialization. Their rhythm should be one of four or five years. The congresses should include a number of symposia introduced by at least two invited speakers with divergent views or with a divergent approach to the subject. Discussion from the floor should be allowed after the introductory papers. Uninvited short papers should be submitted to previous scrutiny, as is customary for the acceptance of a paper in a scientific journal. It was also decided that specialized conferences (symposia) with no more than twenty to twenty-five participants should be held between the general congresses. The Executive Committee of the Union should study the question of publication of the proceedings of the symposia in order to reach a certain degree of uniformity.

The last topic of the symposium, which dealt with "International Co-operative Projects", should have been introduced by B. Rensch (Zoologisches Institut, Münster), but he was unfortunately not able to attend, and J. Runnström took the chair in his place; Dr. Rensch's paper was read by Dr. L. Harrison Matthews (London). R. Hiatt (Hawaii Marine Laboratory, Honolulu) and E. Aichinger (Landesinstitut für Pflanzensociologie, St. Georgen am Sandhof, Austria) were the two invited speakers; but the latter was absent. Rensch expressed the opinion that the barriers raised by differences in language are greater than they should be, and that more personal contact would help to remove these hindrances to the more complete utilization of scientific experience. In some fields of biological research, international co-operation is imperative: such are the biological problems presented, for example, by the oceans and the polar regions. International co-operation is also essential within certain borderline fields between biology and other sciences, as, for example, biometry, biophysics and biological philosophy. Hiatt's special concern was international co-operative projects in marine biology; this matter was more exhaustively discussed in a symposium on marine biological laboratories held under the auspices of the Union a week later (see *Nature*, June 18, p. 1062).

In conclusion, it may be said that many of the resolutions or suggestions which came out of the discussion at the symposium were adopted by the General Assembly of the International Union of Biological Sciences, or will guide the future policy of the Executive Committee of the Union.

BREEDING LABORATORY ANIMALS

THE use of laboratory animals in nearly all branches of biological research has been steadily increasing for several decades and, as was to be expected, it has kept in step with the general increase in work of this kind. Moreover, the usefulness of animals, and in particular of the smaller mammals such as the common laboratory rodents, in investigating and assaying drugs and other therapeutic substances not susceptible to chemical standardization accounts to-day for a very large proportion of all laboratory animals used in Britain and in most other countries[1]. Concomitant with this increased use has developed the demand for quality, so that to-day laboratory animals tend to be regarded more or less as reagents. Among the essential qualities of any reagent are some indication of its purity, or at least its degree of contamination, and also the requirement that it should be perennially reproducible. This implies that attention must be given to the methods of producing these biological reagents[2].

In the past much reliance has been placed upon animals supplied by breeders or dealers whose main interest is to offer suitable animals for sale upon such terms as will afford them reasonable business profits. There is much to be said for this system in that it relieves laboratory workers of the burden of manufacturing their own reagents, and, provided the quality of the animals supplied in this way is of a high enough standard, there is every reason to suppose that the commercial breeder or supplier will remain in the field indefinitely.

This proviso, however, is an important one, because to-day the laboratory worker's demands for animals of a given specification are more exacting than ever before. For certain types of animal, commercial sources cannot hope to provide suitable material, and the laboratory worker is driven, often rather reluctantly, to breed his own animals. Such instances as inbred strains of mice for cancer research, and the production of litter-mate groups, may be cited. It has now become quite evident that, in order to obtain animals of the quality required, it is often necessary to breed them under laboratory conditions and in considerable numbers—numbers such as will satisfy the greater part of the demands of, say, all the laboratories of a single university.

It was therefore timely that a symposium on the breeding of laboratory animals should have been arranged by the Laboratory Animals Bureau, and was held at the Royal Society of Medicine on May 9, with Prof. E. C. Amoroso, of the Royal Veterinary College, London, in the chair. The papers read at the symposium will be published in the "Collected Papers", Vol. 3, of the Laboratory Animals Bureau (obtainable from the M.R.C. Laboratories, Holly Hill, Hampstead, London, N.W.3).

Mr. A. L. Bacharach (Glaxo Laboratories, Ltd.) opened the symposium with a paper entitled "Some Aspects of Animal Production for Routine Biological Assay". He treated his subject mainly from the point of view of the user, and he drew largely from his experience of the colonies of rats and mice which have been maintained for many years by the Glaxo Laboratories at Greenford. These colonies were set up in order to fulfil the exacting demands of the bio-assayists, and Mr. Bacharach played a prominent part in their establishment. Experience at Greenford

has shown that ample reward in the way of more uniform animals, and therefore better reagents, has been obtained, not only by closely regulating the environment in which the animals are bred but also by achieving further uniformity through inbreeding. The combination of genetic uniformity and an optimum uniform environment has added little to the cost of animal production.

Dr. H. Grüneberg (University College, London) spoke about "The Genetical Aspects of the Breeding of Laboratory Animals". In considering whether uniformity might be best achieved by the use of strictly inbred animals, by their first- or second-generation crosses, or by randomly mated members of a comparatively large population, he directed attention to the fallacy of *a priori* reasoning. In respect of some thirty-one morphological characteristics in mice, he showed that the variance in inbred strains and in their *F*1 and *F*2 crosses is quite unpredictable. The inbred strains may have a high or low variance for any particular characteristic; so also may crosses between strains, and it may be greater or less than that of either parent strain, so that in any single instance the degree of variance can only be discovered by investigation. What is true for morphological features is likely to be equally true for physiological responses. It follows that for every test where maximum uniformity is of value the merits of each case must be examined individually[3].

The third paper was given by Dr. D. Michie (Department of Zoology, University College, London) and was entitled "Towards Uniformity in Experimental Animals". Dr. Michie pointed out that, whereas inbred strains possess the maximum genetical uniformity, the phenomenon of inbreeding decline may render them particularly sensitive to small changes in the environment. In this way the phenotypic variance may be, and frequently is, greater than is to be expected on the assumption that variance from genetical and environmental causes is merely additive. If, however, two inbred but comparatively unrelated strains are crossed, the resulting progeny will possess a full measure of hybrid vigour because they will be to a large extent heterozygous; but, because their parents are homozygous, the genetical pattern of the first generation progeny will be as uniform as that of the parents. In such an instance, therefore, it is possible to obtain genetically uniform animals with all the vigour conferred by the heterozygous state and thus far less susceptible than their parents to small changes in the environment[4,5].

Dr. Anita M. Mandl (Department of Anatomy, University of Birmingham) spoke about "The Value of Litter-mate Controls in Endocrinological Research". For this type of work her own experience leaves no doubt that in problems involving a limited number of treatments the use of litter-mate controls gives far greater accuracy, or conversely requires far fewer animals, for a given degree of accuracy. This does not necessarily follow, she continued, in the field of bio-assay. Indeed, for much work of this kind it may be difficult to provide litter-mate controls.

The points arising from the morning session of the symposium emphasized once again the importance of choosing the right animal for the purpose. No rules, are generally applicable to every case, but time spent on making a proper choice will be more than counterbalanced by increased accuracy or by economy in the use of animals. As Dr. Mandl pointed out, the recording necessary to produce animals of known family history is a burden so small as to be almost negligible.

The afternoon session was opened by Prof. J. E. Nichols (Department of Animal Husbandry, University College of Wales, Aberystwyth), who discussed "The Principles of Animal Production". He referred to the production of farm animals for particular purposes, and it was implicit in his remarks that breeding, for example sheep, for special characteristics involved the same principles as breeding laboratory animals. There was much to be learnt about the breeding of laboratory animals from a study of modern farm-stock breeding practice.

Dr. J. S. Perry (formerly of the Agricultural Research Council Field Station, Compton, and now at the Agricultural Research Council Institute of Animal Physiology, Babraham) gave a paper on prenatal loss as a cause of reproductive wastage. By no means every ovum shed may be fertilized, and there is an inevitable and variable loss from among those fertilized which never survive to be born. Whether or not this almost universal prenatal wastage has a value under natural conditions, there can be no doubt that in the less rigorous environment of the laboratory it is worth attempting to reduce it so that the maximum reproductive potential may be more nearly approached.

Dr. I. W. Rowlands (Institute of Animal Physiology, Babraham) spoke on postnatal causes of reproductive wastage. There is little advantage, he said, in an embryo surviving the hazards of uterine life only to succumb to the further hazards of the period between birth and weaning. Some of these latter hazards are inherent in the dam or the offspring. Others, however, are largely influenced by the circumstances of the breeding colony. In either case losses should not be accepted with complacency.

The last paper was given by Dr. C. S. Grunsell (Royal (Dick) School of Veterinary Studies, Edinburgh); Dr. Grunsell is curator veterinarian of the small-animal breeding station at the University of Edinburgh, and he spoke from his own experience of the problems besetting anyone in such a position. One of these problems is the old one of fluctuating demand which too seldom keeps in phase with supply. A university breeding station serving a single university, he said, is probably the right sort of size to aim at and has the advantage of administrative convenience. It should be capable of supplying most of the requirements of different university departments for most species of laboratory animal. At least in its early stages it cannot be expected to produce animals down to an economic figure, and perhaps it may never compete successfully in terms of hard cash with the commercial market, although it is impossible to say that this must necessarily be so. It should, however, provide a much better service to university departments than they can generally obtain either from the commercial market or from setting up departmental, and usually thoroughly uneconomic, units of their own.

As Prof. Amoroso pointed out in his summary, we are not far removed from the beginning of our knowledge in this important field, and it would be premature at this stage to pay too much attention to the economic aspect. Indeed, comparatively little is known even about the actual cost of breeding laboratory animals. Those laboratories that do possess figures show as great variations in their costs of breeding as they do in their methods, and too many laboratories appear to have little or no idea of

just how much their animals are costing them. But the cost of breeding is only one item. The cost of wasted time and frustrated research resulting from the use of unsuitable or inferior animals can never be properly calculated. One point, however, is clear beyond doubt: the breeding of laboratory animals is no longer a matter for the amateur, if indeed it ever was. It has become a special subject in its own right.

The general conclusion arising from points discussed at this symposium is that there is an urgent need for far more information about the characteristics and responses of different types and strains of laboratory animals, and that this information should be handled much more than it is on an international basis. For example, it is not sufficient in referring to work in which animals are used to describe them as just 'mice', or even as 'CBA mice', for even a named inbred strain may not be the same in two different laboratories. Mouse geneticists and cancer workers have shown what can be done with defining inbred strains of a single species[6], and the "Catalogue of Uniform Strains" of the Laboratory Animals Bureau represents a step in a rather different and perhaps more widely applicable direction. More recently, the "Handbook of Laboratory Animals" of the American Institute of Animal Resources[7] has made a further contribution. But these lists are only a beginning. They are in themselves incomplete and only serve to emphasize the need for a world-list of laboratory animals, fully annotated and periodically kept up to date. The preparation of such a list would be a considerable labour, but the means of compiling it should not be difficult to find; there can be no doubt of its ultimate great value to all who use laboratory animals.

W. Lane-Petter

[1] Lane-Petter, W., Lab. Anim. Bur. Coll. Pap., **1**, 7 (1953).
[2] See *Brit. Med. J.*, **1**, 558 (1942).
[3] Grüneberg, H., *Nature*, **173**, 674 (1954).
[4] Maclaren, A., and Michie, D., *Nature*, **173**, 686 (1954).
[5] Biggars, J. D., and Claringbold, P. J., *Nature*, **174**, 596 (1954).
[6] Carter, T. C., Dunn, L. C., Falconer, D. S., Grüneberg, H., Heston, W. E., and Snell, G. D., *Cancer Res.*, **12**, 602 (1952).
[7] See *Nature*, **175**, 264 (1955).

FOURTH COMMONWEALTH HEALTH AND TUBERCULOSIS CONFERENCE

THE fourth Commonwealth Health and Tuberculosis Conference, organized by the National Association for the Prevention of Tuberculosis, was held in the Royal Festival Hall, London, during June 21–24 and was attended by more than thirteen hundred delegates from the United Kingdom and the Dominions and Colonies, from the United States, and from various parts of Europe, Asia and Africa. Fifty-eight different countries were represented. The scientific programme had been skilfully planned to appeal to the wide variety of interests represented by chest physicians, radiologists, medical and lay administrators, industrial medical officers, matrons, nurses, social workers and physiotherapists, and consisted of discussions on the following topics: preventive outlook; child hygiene and infection; choice of drugs in medical and surgical treatment of tuberculosis; death-rates; X-ray and tuberculin surveys; tuberculosis as a problem of different races; psychology of the patient and relatives as a factor in successful treatment; tuberculosis in industry; tuberculosis and leprosy; and rehabilitation.

In the session on the preventive outlook to-day, Dr. P. V. Benjamin, technical adviser in tuberculosis to the Government of India and the first recipient of the Sir Robert Philip Medal of the National Association for the Prevention of Tuberculosis for his outstanding contribution to the control of tuberculosis in India, stressed the many difficulties besetting the introduction of preventive measures on an extensive scale in his country. There are few doctors with a real aptitude for this type of work, and the majority of those specially trained are more interested in the clinical aspects. One of the steps under consideration by the Government of India is a re-orientation of medical education to lay increasing emphasis on prevention and social medicine. A BCG vaccination campaign was launched in 1948, and it is intended that all the susceptible population, numbering nearly 170 million, should be tuberculin-tested and BCG-vaccinated by 1960. So far, more than 57 million people have been tuberculin-tested, and 18 million vaccinated, with an average monthly turnover of 2½–3 million.

In the discussion on the choice of drugs in the treatment of tuberculosis, Dr. Walsh McDermott, editor of the *American Review of Tuberculosis*, described isoniazid as a revolutionary drug which has made possible the domiciliary treatment of the disease in outlying places. There is also a strong possibility that it may be used for prevention. In his experience, isoniazid given alone has proved as effective as, and even better than, combined therapy with streptomycin and *p*-aminosalicylic acid, for example. Dr. O. F. Thomas, of Aintree Hospital, Liverpool, emphasized that, in the absence of reliable laboratory methods for establishing drug sensitivity of the tubercle bacillus, it is all the more important to be familiar with the previous history of drug treatment in any given case. Dr. Brendan O'Brien, of Dublin, presented a preliminary report on the clinical use of a new molecular combination of isoniazid, thiosemicarbazone and starch ('Hinconstarch') in nine patients with varying degrees of tuberculosis, seven of whom became sputum-negative. The drug was well tolerated, and there were no toxic effects on any system. Dr. Frank Retief, chief medical officer to the Witwatersrand Native Labour Association, Johannesburg, communicated an interesting paper on the results of isoniazid therapy in African miners with open pulmonary tuberculosis. The most striking effects were euphoria and increase in appetite. Of the forty-five patients treated, 68 per cent gave a sputum reversal to negative after three months, and 80–90 per cent showed improvement radiologically, particularly during the first four to six weeks after beginning treatment.

In the session on tuberculosis as a problem of different races, Dr. T. F. Anderson, director of medical services, Kenya, stated that, in the absence of specific treatment, pulmonary tuberculosis in the African patient runs a rapidly fatal course; but that the response to modern chemotherapy is extremely good, even in cases showing widespread disease. According to Dr. Riaz Ali Shah, associate professor of tuberculosis at King Edward Medical College, Lahore, many complex and variable factors are concerned in influencing the speed of decline of morbidity and mortality from tuberculosis in various ethnic

groups, such as economic factors, genetic elimination of susceptible persons and educational campaigns, so that tuberculosis is inherently not a racial problem.

In the discussion on tuberculosis and leprosy, the late Dr. John Lowe, in a paper read for him by Dr. E. Muir, honorary medical adviser, British Empire Leprosy Relief Association, suggested that the varying susceptibility of different persons to leprosy might be related to the presence or absence of acquired immunity to tuberculosis. Compulsory isolation in his opinion is unscientific, impracticable, ineffective and inhuman. He concluded by saying that leprosy is not a disease apart, but that it is a general public health problem; that public health, and not public fears and prejudices, should determine the policy of leprosy control.

An attractive and informative exhibition, spaciously housed, was organized in conjunction with the conference and included a mass-radiography unit at work; technical apparatus; drugs; books and periodicals; occupational and art therapy; scientific exhibits from various hospitals; examples of work done by administrators, doctors and patients in the British Colonies; and an exhibit of the Ministry of Agriculture, Fisheries and Food illustrating the rapid progress made since the end of the Second World War in the eradication of bovine tuberculosis in cattle. Some very interesting short films were shown, and the conference ended with a number of visits to hospitals, sanitoria and other institutes specially connected with problems of tuberculosis.

W. R. Bett

MUSEUMS ASSOCIATION

CONFERENCE IN BIRMINGHAM

FOR its sixty-first annual conference, held during July 4–9, the Museums Association returned to Birmingham, which was last visited in 1932. The 1955 Birmingham conference was, however, about twice as large as its predecessor, being attended by about three hundred and fifty delegates, including fourteen from overseas. The Barber Institute of Fine Arts in the University of Birmingham provided ideal headquarters, with lecture theatres. In the absence through illness of the president of the Association, Sir Leigh Ashton, the chair was taken by the vice-president, Dr. F. J. North. In a presidential message, Sir Leigh paid a sincere tribute to those in industry who are aware of the value of the vital part played by design in the manufacture of consumer goods; he recalled that in the Victoria and Albert Museum, London, are many objects from Birmingham, especially those illustrating the craft of the silversmith. Dr. North then gave a much-appreciated survey of the main activities of the Association during the past year, specially stressing the important acquisition of new headquarters, the increasing value of the diploma, and the initiation of the technical certificate.

Mr. John Summerson (Sir John Soane's Museum, London) gave the first paper, which was on museum buildings as architecture, and said that Smirke's design for the British Museum was in essence the English collegiate conception. In the Oxford University Museum of 1855 progressive ideas came forward, and it may be considered as a conscious attempt to go one better than the great new railway stations of the period. During the afternoon of July 5 the archæological section of the conference had three papers. Mr. R. L. S. Bruce-Mitford (British Museum) discussed the functions of national and local museums as regards the acquisition of material, and he stated that the British Museum can now carry out excavations of its own, and one is now in progress at Hodhill in Dorset. Prof. C. F. C. Hawkes (Oxford) outlined the great advantages of "Inventaria Archæologica", a handy compendium of selected material, printed not in volumes but on uniform and inexpensive cards. These are planned to cover the widest possible range of types, periods and cultures, and about two hundred British cards should be ready by 1960. Dr. D. B. Harden (Ashmolean Museum, Oxford) concluded the afternoon session; he maintained that the primary object of the public in visiting museums is recreational.

On July 6, Mrs. Lydia Bond-Powel described the American Wing of the Metropolitan Museum of Art, New York; this is devoted to the chronological development of the interior architecture and decorative arts in the American Colonies and the early Federal period of the United States. Mr. Iolo Williams strongly advocated the formation of a museum of oil paintings. He stated that there is no museum which collects paintings not primarily as works of art but as paintings. This constitutes a serious deficiency in the study of painting, and it should be possible for museums to rectify the position by the formation of reference collections for the art historian. Prof. Ellis K. Waterhouse (Barber Institute) pleaded for a closer co-operation between art teachers and museum officials and the widening of the fellowship of the Association to include those who are chiefly concerned with the teaching of art history. Prof. W. G. Constable (Boston Museum of Fine Arts, Mass.) made a number of suggestions regarding the place of museums in this changing world, some of which were of a rather revolutionary character. Mr. Norman Bertenshaw, describing the organization of the new Museum of Science and Industry in Birmingham and the way in which the Elkington electro-plate factory has been adapted for the purpose, stated that the policy of the Museum is to stimulate the interest of the visitor rather than attempt the portrayal of a complete developmental sequence, since it is felt that the latter is more properly the function of the national museums. Dr. F. Sherwood Taylor (Science Museum, London) ably outlined the functions of museums in relation to children and science, and maintained that it is essential for instruction to be provided through pleasure; it is desirable that the exhibits should tell their own story and not rely upon written labels. Finally, Prof. H. Graham Cannon (University of Manchester) gave an instructive and practical paper on aquaria in museums.

A session, open to the public, was held on July 9, when Sir Mortimer Wheeler gave an admirable summary of past negotiations regarding State aid to museums in Great Britain and advocated the formation of a museum grants committee comparable to the University Grants Committee. Sir George Dyson, chairman of the Carnegie Trust, felt that the position of museums is illogical in that the Government has accepted responsibility for the national museums but defines national as London. The provinces pay taxes for the national museums grant and are also expected to support their own museum.

During the week, tours were arranged to the museums of Birmingham and Warwick, an archæological site at Weoley Castle, Althorp, the seat of Earl Spencer, and a tour of the canals to Wolverhampton. At the meeting, Dr. F. S. Wallis (Bristol) was elected president for 1955–56, and it was decided to hold the next conference in Amsterdam, probably at the end of June 1956.

THE NATIONAL OCEANOGRAPHIC COUNCIL

ANNUAL REPORT FOR 1953-54

THE National Institute of Oceanography is now firmly established at its new premises at Wormley, near Godalming, Surrey, and the Discovery Committee collections and staff are comfortably housed there, apart from a small group still accommodated at the British Museum (Natural History).

In the Institute's report on research during the year April 1, 1953–March 31, 1954*, two topics of particular interest on the physical side are the relationship between waves, wind and swell, and the transfer of energy between air and sea; these studies have involved not only the co-operation of the Liverpool Tidal Institute but also that of the Department of Meteorology of the Imperial College of Science and Technology, London. An expedition, made possible by a grant from the Royal Society, was run jointly with the latter to investigate energy exchange between air and sea at the flat Island of Anegada in the West Indies. Much important data were gathered and will be reported in detail by Prof. P. A. Sheppard, Mr. H. Charnock and others. Several pieces of new apparatus have been developed or improved. These include improvements to the electro-mechanical filter of the wave analyser, further developments to the electromagnetic flowmeter and a new type of recording camera which takes 175 ft. of photographic paper. In collaboration with Kelvin Hughes, Ltd., Dr. J. N. Carruthers has developed a 'streamed cone' current meter allowing for instantaneous measurements of current speed and direction.

On the biological side, advances have been made in the study of krill (*Euphausia superba*), which is the main food of the larger animals in the Antarctic. Mr. J. W. S. Marr has been able to establish that this organism is confined to Antarctic waters and lies mainly in the drift from the Weddell Sea and in the East Wind Drift close to the continent. A comparable study of the chætognath, *Sagitta gazellae*, has nearly been completed by Mr. P. M. David. Mr. A. de C. Baker has shown that common species of phyto- and zoo-plankton have a circumpolar range and leaves little doubt that populations are continuous around the antarctic circle. Further work is being carried out on the material brought back from the expedition on the Royal Research Ship *William Scoresby* to investigate the Benguela Current.

There is still much study to be done on the large collections built up under the Discovery Committee, and a number of specialists are engaged on this. The most recent work to be published on these collections was Captain A. C. Totton's monograph on the Siphonophora of the Indian Ocean. Considerable work has been carried out through international collaboration on whale-marking, thanks largely to a number of whaling companies for lending a modern diesel-driven whale-catcher, the *Enern*. In addition, a number of papers by members of the staff have been published which are important to the study of the life-history and migration of whales.

The Royal Research Ship *Discovery II* has been refitted with a number of new items, including an up-to-date radar set and position-finding equipment. The 1954–55 programme includes a study of deep-water movements in respect of density distribution and other factors. The biological work includes new methods of sampling and observing deep-sea organisms. Investigations will also be carried out using the carbon-isotope method for studying photosynthetic activity. In addition, the ship will also provide facilities for the Admiralty, Sir Edward Bullard and the University of the West Indies for various research purposes. After twenty-eight years of service, the *William Scoresby* has sadly been put in the hands of the shipbreakers. She operated largely as a whale-marker, but during the Second World War served as a minesweeper and patrol vessel in the Falkland Islands area; in 1949 she returned to her work of whale-marking, but only managed one cruise in this capacity under the National Oceanographic Council.

This account of the work of the Council is only a brief summary, and of necessity much of interest has had to be omitted; but much credit is due to the Council and to the energies of Dr. G. E. R. Deacon, director of the National Institute of Oceanography, and his staff for the rapid development of research after the major upheaval of changing premises and equipping new laboratories. C. D. OVEY

* Annual Report of the National Oceanographic Council, 1 April 1953–31 March 1954. Pp. v+28. (Cambridge: At the University Press, 1955.) 5s. net.

THE GOLDEN EAGLE IN AMERICA

THE golden eagle (*Aquila chrysaetos canadensis*) is widely distributed in mountains and adjacent plains throughout much of the northern hemisphere. Its principal breeding-range in North America extends from the Arctic Ocean south into Mexico, westward from the 99th meridian. As it nests from near sea-level to the timber-line, it may be found in a wide variety of habitats and in winter it occurs practically throughout this country. Its food habits are as varied as the diversified habitats in which it lives. These, and the economic status of the eagle, have been described by Lee W. Arnold in a publication of the Fish and Wildlife Service of the United States Department of the Interior (Circular 27).

The golden eagle has been known to kill and eat more than sixty different kinds of animals, ranging from full-grown deer and antelope to mice, birds, frogs and insects. Both living creatures and dead are included in its diet, and at times it accepts carrion even though living prey is available.

Rabbits and rodents form the staple diet of the golden eagle, the proportion taken varying with local conditions. During the nesting season on a Colorado antelope range, rabbits supplied most of the golden eagle's food; under winter conditions on a North Dakota pheasant refuge, they comprised approximately 19 per cent.

On occasion, the bird will kill adult and young antelope, although in northern Colorado, where four pairs of eagles nested in close proximity to antelope at fawning time, such predation was negligible.

Although the golden eagle will kill either the adult or the young of deer, no evidence was found to indicate that the bird is more than a minor influence when compared to other factors controlling deer populations.

Depending on local conditions, the golden eagle exerts a varying pressure on upland game birds, and at times this pressure may be sufficient to warrant eagle control. The harassing of upland game, thus keeping them from feeding properly in severe weather, may be more serious than the actual killing activities of the eagle. When nesting in the vicinity of waterfowl areas, the golden eagle may feed its young largely on these birds.

Golden eagles at times kill domestic lambs. The extent of this damage varies with local conditions. On occasion, they kill calves or may even contribute to the death of full-grown cattle. All evidence indicates that this is an exceptional activity.

Golden eagles occur in varying numbers on more than sixty-five Federal wild-life refuges where, in general, they serve a beneficial purpose in consuming wounded, sick or dead ducks and forage-consuming jack-rabbits and rodents.

RESEARCH ON FOREST PRODUCTS

THE strength properties of plywood have already been considered in Bulletin No. 29 of the Forest Products Research Laboratory, Princes Risborough, entitled "Comparison of 3-Plywoods of a Standard Thickness, Part 1" (see *Nature*, 174, 383; 1954). In Bulletin No. 33 on "The Strength Properties of Plywood, Part 2: Effect of the Geometry of Construction"*, the author states that an increasing demand for data on the mechanical properties of plywoods exists; but owing to the wide variety of constructions and thicknesses now available, it is not possible to obtain these data by testing procedures alone. To cover the whole field, some simple methods for estimating strength from limited basic data are required, and this the author sets out to do. This investigation has become necessary because plywoods have become a structural material and can now be produced in forms practically indestructible by delamination. It is stated that increasing quantities are being used, for box and web types of girder, panel floors and walls, ship's planking and concrete shuttering. The trouble is the large variety of thicknesses and different forms of construction, all of which cannot be tested. The coming of plywood in this extensive form of utilization will be very beneficial to the tropical and subtropical forester in charge of forests containing large mixtures of species of trees of which until comparatively recently only a few luxury timbers were marketable. A number of others are now being used, and sylviculturally the management of the forests should become more intensive with the improvement of working plans.

The Bulletin contains the results of an investigation to provide suitable equations for calculating the bending, tension, compression and shear strengths of any plywood construction. All the tests are carried out on African gaboon. From the results, equations have been formulated which can be used in practice for calculations or constructions of any other species of wood. An appendix to the Bulletin shows how they can be applied.

Bulletin No. 32 of the Forest Products Laboratory entitled "Field Tests on Wood Preservatives used for Pressure Treatment"* describes experimental work carried out during 1929–53. The lengthening of the life of wood for the various purposes for which it has for so long been used by man has always been a factor for some consideration, especially in tropical countries where perhaps the matter has been more in the forefront of both forester and wood user. So long ago as the 1860's, when railway construction was being carried out on an intensive scale in northern India, the supplies of the valuable Himalayan deodar threatened to give out, and sleepers were cut from the *Pinus longifolia* which was abundant in the lower hills. Creosote was brought out from Britain and applied cold without any protective effect. It was more than half a century before the railway authorities tried this timber again for the purpose.

In temperate climates, in Europe at least, some form of preservative for wood structures has for long been under experiment. So far the high-temperature creosotes have proved to be the most effective preservative under test. The method employed is to set out a small 'graveyard' of small blocks of a perishable wood (the agar wood is chiefly used) and these are treated with graded concentrations of the preservative under test, untreated wood blocks being side by side with the treated ones. The treated blocks are kept for a few months with a specific fungus growing on a nutrient agar medium. Periodical examination of the blocks is undertaken, one of the tests being done at Princes Risborough, a second at Thetford and the third at Dolgelly. None is as yet complete.

The results already obtained, however, do give some indication of how effective most of the treatments are likely to be. So far, the high-temperature creosotes have proved to be the best preservative under test; all are highly effective, and after twenty years there is no sign of any difference between them. The low-temperature creosotes, however, do not appear to be quite so effective. At present there is not much to choose between the various modern water-soluble preservatives under test, although 'Ascu' appears to be the most promising. E. P. Stebbing

* Forest Products Research. Bulletin No. 33: The Strength Properties of Plywood. Part 2: Effect of the Geometry of Construction. Pp. iv+28+4 plates. By W. T. Curry. (London: H.M.S.O., 1954.) 2s. net.

* Forest Products Research. Bulletin No. 32: Field Tests on Wood Preservatives used for Pressure Treatment. By D. N. Smith. Pp. iv+52+1 plate. (London: H.M.S.O., 1954.) 2s. 6d. net.

SPITSBERGEN TERTIARY COAL FOSSILS

SVEIN MANUM has reported on the pollen-grains and spores to be observed in coal deposits of Tertiary age in west Spitsbergen (Norsk Polarinstitutt, Med. 79, pp. 1–9; 1954; English summary).

The Tertiary formation, of Palæocene–Eocene age, comprises several coal seams of which a preliminary analysis of the contents of pollen and spores has now been made. The numbers of microfossils, as well as their state of preservation, are highly variable. All grains and spores are completely flattened in the coal and do not regain their round shape after maceration. The pollen and spores thus far observed have

been referred to fifty-two sporomorphs, most of them resembling species already described, in particular from the German lignites. Some twenty sporomorphs, however, are considered to be new. Descriptions and names have not been attempted in the present paper; but some of the most characteristic sporomorphs have been illustrated, and indications of their affinities given. A comparison has also been made with the genera that are known as macrofossils.

Nathorst mentions six such species of pteridophytes, while twelve sporomorphs indicate that this group was represented by a considerably larger number of species. Most of the spores are referable to the Polypodiaceae and Osmundaceae. The Lycopodiaceae are not known as macrofossils; but one of the spore types seems to belong there.

The gymnosperms are abundantly represented as macrofossils (twenty-seven species, among them twenty-four conifers) as well as pollen. Among the winged pollen grains some have a strong resemblance to *Abies*—a genus not so far found as a macrofossil. Among gymnosperm pollen grains without wings there are two which somewhat resemble *Sciadopitys*—another genus not observed as a macrofossil.

The Betulaceae, Fagaceae and Salicaceae are represented by more than twenty species of macrofossils, and correspondingly a large number of pollen grains belong to this group. Some grains also recall the Myricaceae, which, however, are not among the macrofossils. Another type resembles the pollen of *Acer*, of which three macrofossil species have been recorded; and so on, materials indicative of affinities with *Alisma*, *Nymphaea*, *Potamogeton* and Ericaceae being recorded. Lastly, some pollen grains have characters recalling those of certain palms (*Sabal*), which are known from the Tertiary of Central Europe, but of which no macrofossils have been found in Spitsbergen.

GROWTH-SUBSTANCES SEPARATED BY CHROMATOGRAPHY

METHODS for the chromatographic separation on paper of indole compounds, and for the direct biological assay of the chromatograms using the *Avena* coleoptile straight-growth method, have been described by N. P. Kefford (*J. Exp. Bot.*, **6**, 16, 129; 1955). Reagents for the detection of the indole-3-carboxylic acids, indole-3-acetonitrile, and gramine as coloured spots on chromatograms are compared, and the areas of such spots are shown to be proportional to the logarithms of the quantities of substance present.

The procedure of chromatography described is shown not to involve a loss of indole-3-acetic acid activity if chromatography is done in darkness and chromatograms are not stored in light and air.

Methods are described for the extraction of growth-substances from plant materials, the purification and chromatography, on paper, of the extracts and the bioassay of the chromatograms using *Avena* coleoptile sections. The ether extracts, containing acidic substances, of etiolated broad bean and pea shoots and roots, etiolated sunflower shoots, maize roots, and potato etiolated shoots and tuber have been chromatographed and the chromatograms bioassayed.

On all chromatograms three areas active in *Avena* coleoptile section growth are found. One area of growth promotion is shown to be due to indole-3-acetic acid. Another area of growth-promotion and one of growth-inhibition are due to unknown substances, which are named accelerator α (α) and inhibitor β (β) respectively. On chromatograms of potato tuber a fourth growth-promoting area, in addition to those described above, is detected and is shown to be probably due to indole-3-acetonitrile. This or indole-3-pyruvic acid may occur together with indole-3-acetic acid on chromatograms of extracts of immature maize kernels and cauliflower head respectively. On cabbage extract chromatograms the growth-promoting activity corresponding in position with indole-3-acetic acid is shown to be due to this acid alone.

CONTROL OF FERTILITY BY ANTIMITOTIC AGENTS

By DR. B. P. WIESNER and PROF. JOHN YUDKIN

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WHILE continuing our studies on naturally occurring substances which might be used in the control of human fertility[1], we have also adopted a new line of investigation into this problem. This has been a study of some of the numerous substances which are alleged to have antimitotic activity, in the hope that one or more might prove effective in controlling fertility. These are the reasons which led us to this approach.

First, some types of human infertility, such as disturbances of spermatogenesis and very early miscarriage, are often associated with disturbances of mitosis and cytokinesis. These effects may be limited to the seminiferous epithelium or to the ovum, and the sterility which they produce is usually not accompanied by detectable signs of ill-health in the man or woman. Secondly, mitotic poisons frequently prevent the development of the fertilized ovum of various aquatic animals. In fact, many such poisons have been discovered by exposing echinoderm eggs to them. Again, it has been found that concentrations of a mitotic poison which readily suppress cleavage of the fertilized ovum need not affect the adult organism.

We have therefore studied the effect on pregnancy in female inbred Swiss mice of a number of antimitotic substances, administered in solution or suspension by stomach tube or subcutaneous injection. In all experiments, control animals receiving the dispersing medium in similar manner remained unaffected. Two examples of active substances so far discovered are given here.

Example 1. *D-usnic acid.* The antimitotic effect of this compound was described by Marshak and Harting[2]. We administered it daily by stomach tube in the form of freshly made solutions in $N/100$ sodium hydroxide at a dosage-level of 1·5 mgm. Administration begun before pairing had no effect on mating, as shown by the occurrence of a vaginal plug. Administration either before pairing or immediately after copulation was usually not followed by pregnancy but by a recurrence of œstrus and of mating. However, notwithstanding continued administration

of usnic acid, there eventually resulted a state of resistance in which copulation was followed by pregnancy. These pregnancies went to term, though the litter-size and growth-rate of the pups suggested somewhat lowered fertility. Some litters were retained and a second generation reared with the view of detecting possible effects upon the progeny; no such effects were observed.

Example 2. *Podophyllotoxin.* The antimitotic effect of this substance was demonstrated by Cornman[3]. We administered podophyllotoxin by subcutaneous injection, either as a solution in aqueous alcohol or as a suspension of microcrystals in water. A single dose of 0·25 mgm. was given to each animal either immediately after detection of vaginal plug or 3, 6, 12 or 14 days thereafter. Pregnancy did not continue in animals treated three days or more after copulation. Administered within twenty-four hours after copulation, podophyllotoxin was only occasionally effective. After interruption of pregnancy, mating again occurred. Podophyllotoxin was again administered, and pregnancy again did not continue. This has been repeated for three successive pregnancies; thus, unlike usnic acid, there is no evidence of a rapidly acquired resistance.

The subsequent fourth pregnancies were not treated and they proceeded to term quite normally. No side effects such as excessive defæcation or vaginal hæmorrhage were detected even in animals allowed to go to the fourteenth day of pregnancy before podophyllotoxin was administered. In each pregnancy, the increase of maternal body-weight corresponded to that of normal gestation. The only systemic effect noted after administration was the rapid loss of gestational gain of weight.

It is possible that the suppression of fertility accidentally observed by Jackson and Bock[4] after the administration of triethylene melamine may not be related to the carcinostatic activity of this substance as such but rather to its more general antimitotic action. As regards podophyllotoxin, Didcock, Picard and Robson[5] have also shown that it interrupts pregnancy at an advanced stage, although their reason for undertaking the experiment was the hypothetical resemblance of tumours to pregnancy. It has been supposed that podophyllotoxin acts by interfering with the blood supply[6]. Since, however, we have found that it prevents the continuation of gestation even before the implantation of the ovum, its activity is more likely to relate to direct action upon the ovum.

Our results encourage us to continue the search for antimitotic substances the ovicidal activity of which may be employed for the screening of agents of possible use in the control of human fertility.

We acknowledge with thanks the gift of D-usnic acid from Mr. H. A. Berens of Messrs. Biddle, Sawyer and Co., of podophyllotoxin from Dr. W. Mitchell of Messrs. Stafford Allen and Co., and of various other compounds from Mr. S. G. Long of Messrs. R. F. Reed, Ltd. We are also indebted to Messrs. Kylon, Ltd., and Messrs. Stafford Allen for financial assistance, and to Mrs. E. M. Blacker and Miss Margaret Rule for technical assistance.

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A METHOD FOR THE LOCALIZATION OF SITES FOR OXIDATIVE PHOSPHORYLATION

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ISOLATION of portions of the respiratory chain involved in oxidative phosphorylation either by inhibitors that block a portion of the chain or by specific substrates that activate only a portion of the chain show that phosphorylation occurs between reduced diphosphopyridine nucleotide and oxygen[1], and cytochrome *c* and oxygen[2,3]. A more exact localization of sites is limited by the availability of specific substrates and inhibitors for all parts of the respiratory chain. Our approach is based upon direct spectroscopic observations of the effect of the initiation of oxidative phosphorylation upon the steady state of the components of the respiratory chain of intact mitochondria[4]. When respiration abruptly increases upon addition of adenosine diphosphate to mitochondria supplied with substrate and phosphate, we observe a consistent gradation of the changes in the steady state along the respiratory chain from an oxidation at the dehydrogenase portion to a reduction of the oxidase portion[5]. On the basis of these observations, we can identify sites for oxidative phosphorylation in the intact mitochondrial system.

The mitochondria were prepared according to the method of Schneider[6] as modified by Lardy and Wellman[7]. The reactions were studied in the usual 'isotonic' medium. The preparations had values of phosphorus/oxygen of about 3 with β-hydroxybutyrate as a substrate[8].

For recording the kinetics of spectroscopic changes we use a double-beam differential spectrophotometer with the two monochromators set at wave-lengths differing by the half-width of the absorption band to be measured. Since only the difference of absorption is measured, the recording is relatively insensitive to non-specific changes of light transmission that occur in the mitochondria[9]. The phosphorylative activity and the respiration are monitored simultaneously by a technique based upon the vibrating platinum microelectrode[4,8]. The pairs of wave-lengths that were used in the recording of the components of the

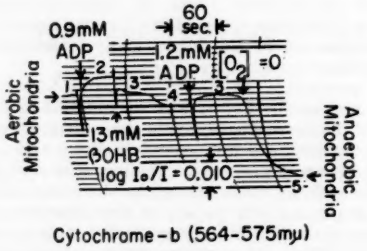

Fig. 1. The various steady states of intramitochondrial cytochrome *b*. Rat liver preparation diluted in complete reaction medium except for substrate and phosphate acceptor. Spectroscopic changes recorded at the wave-lengths indicated with a double-beam spectrophotometer. An upward deflexion indicates a decrease of optical density at 564 mμ (Exp. 348 *b*, *c*)

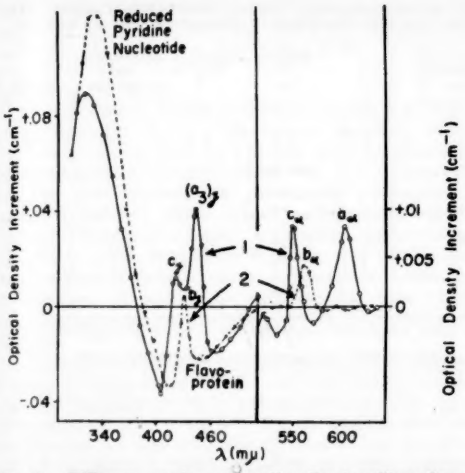

Fig. 2. Difference spectra representing the transitions from aerobic mitochondria (state 1) to anaerobic mitochondria (state 5) and from the fully oxidized state 2 to the antimycin-A inhibited state. The peaks of the various cytochrome bands are identified on the figure. Rat liver mitochondria, β-hydroxybutyrate as substrate (Exp. 432 *d*)

respiratory chain are given in Table 1. The observations reported in this paper are limited to the six components that can be separately recorded at these wave-lengths. Other components, not resolved spectroscopically, are omitted from the present discussion because their function in the phosphorylating respiratory chain cannot be incisively evaluated. Examples of such omissions are Slater's factor[10], cytochrome *c*[11], mitochrome[12] and vitamin K[13].

States of the mitochondrial respiratory chain. The respiratory enzymes exist in a wide variety of states of reduction, as illustrated by Fig. 1 for intramitochondrial cytochrome *b*. The mitochondria as diluted in the isotonic reaction medium (containing phosphate, but no substrate) are in state 1. Addition of adenosine diphosphate causes a rapid initiation of respiration (see ref. 8, Figs. 1 and 2) and oxidative phosphorylation. Spectroscopically, the double-beam instrument records a decrease of optical density at 564 mμ with respect to 575 mμ (note upward deflexion of the trace after addition of adenosine diphosphate). This change corresponds to an oxidation of cytochrome *b* (see Table 1). Since only endogenous substrate is present (usually equivalent to 30 μ*M* oxygen) and excess adenosine diphosphate (900 μ*M*) was added, state 2 is soon reached in which excess adenosine diphosphate is present and negligible respiration occurs (see Table 2). Independent controls show that all the components of the chain are completely oxidized in state 2. Now addition of substrate rapidly reduces cytochrome *b* (and all the other components to varying degrees) and initiates rapid respiration and phosphorylation (ref. 8, Fig. 1). This is state 3, characterized by high activity. It is terminated when the added adenosine diphosphate is used up and the respiration abruptly decelerates (ref. 8, Fig. 1). Then state 4 is reached, a quiescent condition. A second addition of adenosine diphosphate causes a transition back to state 3. This time state 3 is terminated by exhaustion of the oxygen dissolved in the medium and the anaerobic state (state 5) is soon obtained.

Difference spectra. The difference spectrum representing the transition from state 1 to the anaerobic state 5 is given in Fig. 2 (trace 1) and shows absorption bands of cytochromes a_3, *a*, *c* and *b* as well as flavoprotein and reduced diphosphopyridine nucleotide. Cytochrome *b*, flavoprotein and reduced diphosphopyridine nucleotide absorption bands are more clearly shown when a transition from the fully oxidized state 1 to reduction of these components is obtained by addition of excess antimycin A (Fig. 2, trace 2). By applying to these optical density changes their actual or assumed molecular extinction coefficients (compare ref. 14), we can calculate the concentration of the members of the respiratory chain relative to cytochrome *a* (Table 3). Observations are included for two types of phosphorylating systems from liver and flight muscle, and for two types of non-phosphorylating systems from liver and heart muscle. The liver mitochondria are distinguished by their large content of diphosphopyridine nucleotide (up to forty times that of cytochrome *a*), which is negligible in the flight muscle sarcosomes and in the non-phosphorylating systems obtained by disruption of mitochondria. The latter systems are relatively deficient in cytochrome *c*, and, in the case of the heart muscle preparation, flavoprotein as well.

The turn-over number of cytochrome *a* is also computed and ascites tumour cells have the lowest value.

Positions of cytochromes b and flavoprotein in the respiratory chain. The function and location of cytochrome *b* in the mitochondrial respiratory chain

Table 1. Pairs of Wave-lengths used in Double-beam Recordings

	O_2	a_3''	a''	c''	b''	reduced flavoprotein	DPNH	β-Hydroxybutyrate
Wave-lengths used (mμ)	445 455		605 630 (590)	550 540	564 575	465 510	340 374	

Table 2. Definitions and Values of Steady States in Rat Liver Mitochondria
Substrate: β-Hydroxybutyrate; Phosphate Acceptor: Adenosine Diphosphate 25°

State	Characteristics					Steady state percentage reduction Components				
	$[O_2]$	ADP level	Substrate level	Respiration-rate	Rate-limiting substance	*a*	*c*	*b*	Flavo-protein*	DPNH
1	> 0	low	low	slow	ADP	0	7	17	21	~90
2	> 0	high	~ 0	slow	substrate	0	0	0	0	0
3	> 0	high	high	fast	respiratory chain	< 4	6	16	20	53
4	> 0	low	high	slow	ADP	0	14	35	40	> 99
5	0	high	high	0	oxygen	100	100	100	150	100

* These values are based upon the amount of flavoprotein that is reduced upon addition af antimycin-A to the mitochondria in state 2 which is ⅔ the state-5 value.

Table 3. Relative Contents and Turn-over Numbers of the Components of the Respiratory Chain of Intact Cells, Phosphorylating Mitochondrial Systems and Non-phosphorylating Succinic or Reduced Diphosphopyridine Nucleotide Oxidase Systems

Material	Source	Experiment	Substrate	Turn-over number of *a* (sec.$^{-1}$)	Relative contents of components				
					a	*c*	*b*	Flavo-protein	DPNH
Mitochondria	rat liver	average of 4	β-hydroxy-butyrate	8	1	1·7	0·9	3·6	19 (40 max.)
Mitochondria	guinea pig liver	average of 4	glutamate	11	1	1·4	0·6	4·4	43
			succinate	27*					
Mitochondria (water and saline washed)	rat liver	432 *d*	succinate	~ 120†	1	very small	0·5	4	very small
Sarcosomes	flight muscle	421 *f*	α-glycerol phosphate	65	1	1·7	0·55	2·2	< 1
Small particles	pig heart	937	succinate	22	1	0·6	0·4	~ 0	~ 0
Intact cells	bakers' yeast	172	ethanol	120	1	3	2·4	3	16
Intact cells	ascites tumour (Ehrlich hyper-diploid)	225	glucose	3	1	2·7	0·33	3	6

* This value approaches 100 sec.$^{-1}$ in special media. † With added cytochrome-*c*, extrapolated to infinite [cytochrome-*c*]

Table 4. Kinetics of Reduction and Oxidation of the Components of the Mitochondrial Respiratory Chain

Component	a_3	*a*	*c*	*b*	Flavo-protein	DPN
Percentage oxidation as respiration ceases (25°)	—	—	68	71	79	84
Rate of reduction at 4° on substrate addition to aerobic system (*μM* Fe/sec.)	—	—	0·015	0·019	0·07	0·064
Rate of oxidation at 25° as 3 *μM* oxygen is added to anaerobic system (sec.$^{-1}$)	158	120	39	20	13	—

has been considered in detail, and a fully developed discussion is beyond the scope of this article. In order to justify the sequence of action of the respiratory enzymes presented in equations 7 and 8, we include in Table 4 a summary of kinetic studies of the oxidation and reduction of the components of the chain as measured by rapid spectrophotometric methods under various conditions: (1) the kinetics of reduction of the components as the oxygen concentration falls to zero due to respiration (given as percentage pigment remaining oxidized); (2) the rate of reduction upon the addition of substrate to state 2; and (3) the rate of oxidation upon adding oxygen to anaerobic mitochondria (states 5–3) as measured in the regenerative flow apparatus[15]. All these kinetic results are consistent with the conclusion that the components react in the sequence in which they are written in equations 7 and 8 below.

Changes in the steady state caused by the initiation of oxidative phosphorylation. By comparing the levels of states 1, 3 and 4 with that of state 2 (the fully oxidized state) and by using state 5 as a reference level (see Fig. 1), we have computed the percentage reduction of cytochrome *b* in these three states (see Table 2). By repeating the experiment at pairs of wave-lengths appropriate to the other components (Table 1) we obtain the results shown in Table 2.

The characteristic change in the steady-state levels caused by the initiation of oxidative phosphorylation in a rat liver preparation (state 4–3 transition) is an increase in the reduction of cytochrome *a*, and a decrease in the reduction, or an oxidation, of cytochromes *c* and *b*, flavoprotein and reduced diphosphopyridine nucleotide. These oxidations of components below cytochrome *a* occur in spite of the four- to ten-fold increased respiration when phosphorylation is initiated. The point along the respiratory chain at which the reduction changes to an oxidation is called the cross-over point, and this lies between cytochromes *a* and *c* as illustrated by Table 2. The position of this cross-over point in the respiratory chain depends upon the balance of oxidase and dehydrogenase activities. Either by choosing a liver (from guinea pig) with a different balance of these activities or by adding azide (~ 100 *μM*) to the rat liver material, the cross-over point is moved down the chain to between cytochromes *b* and *c*. At higher azide concentrations, the cross-over point lies between reduced diphosphopyridine nucleotide and flavoprotein, no cross-over point between cytochrome *b* and flavoprotein having been identified.

Specific uncoupling agents such as dinitrophenol, dibromophenol, and butyl 3 : 5-di-iodo, 4-hydroxy benzoate, when added to the mitochondria in state 4, cause oxidations and reductions along the respiratory chain similar to those caused by adenosine diphosphate.

Note added in proof. The same state 4–3 transition is observed in intact yeast cells when the intracellular hexokinase activity is used to raise momentarily the intracellular adenosine diphosphate level. The crossover point lies between cytochromes *a* and *c*.

Action spectrum for adenosine diphosphate. So far, we have afforded no proof that the spectroscopic changes illustrated by Fig. 1 and measured at other pairs of wave-lengths given in Table 1 are actually due to the respiratory enzymes named. We have therefore repeated the experiments indicated in Fig. 1 at a variety of wave-lengths and have plotted the resulting optical density changes for the state 2–4 and 3–4 transitions in Fig. 3. Two technical points need to be noted: (1) the spectroscopic data are not continuous, but spot checks in the regions omitted indicate that no large absorption bands have been missed; and (2) the optical density changes in the region 580–620 mμ are for a guinea pig and not a rat liver preparation; but the curve is plotted in accordance with the magnitude of the change for a rat liver preparation as given in Table 2.

Remembering that the difference spectra represent the transition from states 3 to 4, the cessation of phosphorylation, we observe in support of the results in Table 2 that there is the appearance of a reduced diphosphopyridine nucleotide band at 340 mμ, of reduced cytochrome *b* at 430 mμ and at 564 mμ, and of reduced cytochrome *c* at 550 mμ. The α-band of reduced cytochrome *a* at 604 mμ disappears, since this component is oxidized. The small change in

flavoprotein absorption at 465 mμ is caused by reduction of the absorbing oxidized form. On initiation of oxidative phosphorylation (state 4–3 transition) the converse series of spectroscopic changes is observed.

The absorption bands observed in this transition closely resemble those of the known members of the respiratory chain, and do not yet indicate that any spectroscopically distinct forms of the respiratory enzymes are required to participate in oxidative phosphorylation. Such direct experiments render unlikely hypotheses that a special abbreviated respiratory chain is required[13] or, in view of the fact that the steady state of many components is affected by addition of adenosine diphosphate, that phosphorylation occurs at only one point in the respiratory chain[16].

A reaction mechanism. A mechanism for oxidative phosphorylation must satisfy two seemingly incompatible requirements of the reactions that occur upon the transition from state 4 to 3: an oxidation of the components of the respiratory chain below cytochrome *a*, together with a four- to ten-fold increase in the respiration-rate[8]. The converse effect, the transition from states 3 to 4 caused by the exhaustion of adenosine diphosphate, in many ways resembles the effects of an inhibitor of the respiratory chain; for example, the effect of antimycin-*A* upon respiration and steady-state levels[14]. In the latter case, cytochromes a_3, *a* and *c* become more oxidized, whereas cytochrome *b* becomes more reduced, the cross-over point for the effect being between cytochromes *c* and *b*. In the presence of azide (see above), the same cross-over point is observed when adenosine diphosphate is exhausted in the state 3–4 transition, the cross-over point identifying the site of action of an unknown inhibitory compound. With antimycin-*A*, the cross-over point is invariant and the extent of reduction of cytochrome *b* as well as the inhibition of electron transport are practically complete. With the state 3–4 transition, cross-over points are identified at three places along the respiratory chain, and, in the case of diphosphopyridine nucleotide, the extent of reduction is more than 99 per cent and, for a tightly coupled preparation, the inhibition of electron transport exceeds 95 per cent[8]. Addition of adenosine diphosphate to the inhibited electron transport chain rapidly increases respiration[8] by removing such inhibitory compounds from these cross-over points, as evidenced by the fact that components below cytochrome *a* can become more oxidized in the transition from states 4 to 3. This view that the withdrawal of adenosine diphosphate involves an inhibitory effect along the respiratory chain, and that addition of adenosine diphosphate reverses this effect, is, of course, in agreement with hypotheses of those who have approached this problem along rather different lines[17,18], but now we are able to indicate the three pairs of respiratory catalysts that are involved in this effect.

Such a current formulation for the reversal-of-inhibition theory is that the oxidation-reduction reaction causes the formation of a high-energy compound with the oxidation product; an example for a particular site of oxidative phosphorylation is:

$$I + c''' + b'' \overset{k_7}{\frown} c'' + b''' \sim I \qquad (1)$$

The formation of adenosine triphosphate takes place by the following reactions:

$$b''' \sim I + X \longrightarrow X \sim I + b''' \qquad (2)$$

$$X \sim I + P_i + \text{ADP} \longrightarrow X + I + \text{ATP} \qquad (3)$$

In state 4 in the absence of adenosine diphosphate (the amount of *X* or *I* being limited) the $b''' \sim I$ compound, an oxidized, inhibited form of the respiratory enzyme, will accumulate and stop the respiration. There are several experimental data which indicate that the current formulation is inconsistent with our experimental results. First, our results show that the reduced, and not the oxidized, forms of the respiratory enzymes accumulate in the inhibited state 4; for example, diphosphopyridine nucleotide is more than 99 per cent reduced in state 4 (see Table 2). Secondly, mitochondria rendered permeable by hypotonic treatment are found still to contain considerable intramitochondrial reduced pyridine nucleotide which does not elicit rapid respiration unless adenosine diphosphate is added. Nevertheless, addition of a solution of diphosphopyridine nucleotide in the absence of added adenosine diphosphate gives nearly as rapid respiration. Thirdly, mitochondria in state 4 appear to contain an amount of high-energy compound roughly equal to their reduced diphosphopyridine nucleotide content. This compound may react with adenosine diphosphate even in the presence of respiratory inhibitors[19]. These results suggest that reduced diphosphopyridine nucleotide is present in an inhibited form in mitochondria in state 4. While similar experiments have not been carried out with cytochromes *b* and *c*, the analogue computer studies (see below) indicate that the reduced forms of these components are also bound by an inhibitor.

A revised hypothesis that is consistent with our experiments is that the reduced, and not the oxidized,

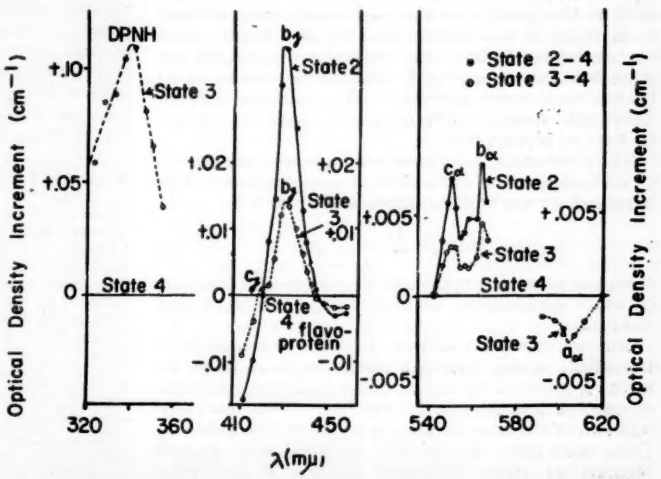

Fig. 3. Action spectrum for adenosine diphosphate, a difference spectrum representing the transition from the active oxidative phosphorylation state (state 3) to the quiescent state 4. The difference spectrum corresponding to the state 2–4 transition is also included. The base-line for both spectra is state 4. (Exp. 359)

Table 5. Oxidation, Reduction and Phosphorylation Reaction Sequence in the Respiratory Chain of Liver Mitochondria

$$O_2 \xrightarrow{k_1} a_3''' \xrightarrow{k_2} a''' \xrightarrow{k_3} c''' \xrightarrow{k_7} b''' \xrightarrow{k_9} \text{fp} \xrightarrow{k_{11}} \text{DPN} \xrightarrow{k_{13}} \text{acetoacetate} \quad (7)$$

$$O_2^- \xleftarrow{k_1} a_3'' \xleftarrow{k_2} a'' \xleftarrow{k_3} c'' \xleftarrow{k_7} b'' \xleftarrow{k_9} \text{rfp} \xleftarrow{k_{11}} \text{DPNH} \xleftarrow{k_{13}} \beta\text{-hydroxybutyrate}$$

$$\uparrow X, P_i \quad \uparrow X, P_i \quad \uparrow X, P_i \quad (8)$$
$$\downarrow \text{ADP} \quad \downarrow \text{ADP} \quad \downarrow \text{ADP}$$
$$c'' \sim I \quad b'' \sim I \quad \text{DPNH} \sim I$$

fp, rfp, DPN and DPNH represent respectively the oxidized and reduced forms of flavoprotein and diphosphopyridine nucleotide

forms of the respiratory enzymes react with the inhibitor I so as to conserve a part of the free-energy change of the oxidation-reduction reaction.

$$I + c''' + b'' \overset{k_7}{\rightarrow} b''' + c'' \sim I \quad (4)$$

the transfer to X being similar,

$$c'' \sim I + X \rightarrow X \sim I + c'' \quad (5)$$

(As is described fully elsewhere, the portion of the free energy charge used to form the $\sim I$ compound could have been conserved when cytochrome c was oxidized in the previous reaction cycle by cytochrome a, and held over until the reduction of cytochrome c by b as in equation 4, at which time the $\sim I$ compound would be formed.)

Equation 4 is ambiguous and has two interpretations. (1) A non-competitive inhibition of respiration in which the formation of $c'' \sim I$ is obligatory and in which $c'' \sim I$ cannot be oxidized by cytochrome a'''. In this case respiration can proceed only if reaction 5 occurs. (2) A competitive inhibition in which the formation of $c'' \sim I$ is not obligatory, and oxidation by cytochrome a can proceed with or without the intermediary reactions leading to phosphorylation. The phosphorus/oxygen (atoms) value of case 1 is fixed; that of case 2 depends upon the relative speeds of formation of the $\sim I$ compound and the competitive oxidation reaction. When the former reaction is rapid compared to the latter, the phosphorus/oxygen (atoms) value for the competitive case rises to that of the non-competitive case.

A transfer reaction initiated by addition of adenosine diphosphate, the state 4–3 transition (cf. equation 5), would cause a definite spectroscopic shift if the spectra of the $\sim I$ compounds differed from those of the uninhibited reduced forms. But our experiments show only absorption bands for the state 4–3 transition (Fig. 3) that can be attributed to known respiratory enzymes. We conclude that no detectable spectral shift occurs in reactions similar to that of equation 5.

Thus the state 4–3 transition releases cytochrome c'' with no spectral shift. The observed spectral shift is caused by the rapid oxidation of c'' by a''':

$$a''' + c'' \overset{k_3}{\rightarrow} c''' + a'' \quad (6)$$

A similar reasoning applies to the observed oxidations of other components of the chain (cf. Fig. 1 and Table 2).

Analogue computer studies. In order to comprehend the effects of the state 4–3 transition more fully, we have represented by means of an analogue computer a reaction sequence involving four of the enzymes and two of the sites for phosphorylation (see Table 5). (The assistance of William Holmes and Joseph Higgins in these computer studies is gratefully acknowledged.) From these and other studies it is possible to make two generalizations concerning steady-state changes following this transition.

(1) For a single phosphorylation site, the component involved will become more oxidized (cf. Fig. 1); the components on the oxygen side will become more reduced, and those on the substrate side more oxidized.

(2) For two adjacent phosphorylations (for example, at c and a), the component nearer oxygen may or may not show an oxidation, whereas the one nearer the substrate will show an oxidation.

From these two generalizations we obtain the very useful cross-over theorem: in the state 4–3 transition, the component on the oxidation side of the cross-over point from reduction to oxidation is identified as a site of oxidation phosphorylation. Depending upon the conditions, cytochromes b and c and reduced diphosphopyridine nucleotide have shown this cross-over behaviour and are identified as phosphorylation sites. According to (2), a component on the reduction side of the cross-over is not ruled out as a possible site. Thus our results do not conflict with those of Lardy[3] or Lehninger[2] on phosphorylation between cytochrome c and oxygen.

The series of reactions of Table 5 summarizes (1) the sequence of spectroscopically detectable components of the oxidative phosphorylation chain, (2) the three locations of the reactions which lead to the formation of inhibitory high-energy compounds, and (3) the transfer reactions by which the inhibitory compounds are decomposed by interaction with adenosine diphosphate (these reactions are abbreviated forms of equations 3, 4 and 5). The advantage of writing the reaction sequence as in Table 5 is that the oxidation and reduction pathways are clearly indicated, and that participants in the individual oxidation-reduction reactions are placed over one another. Such a sequence includes only those components detectable by these methods and represents only single electron reactions.

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LETTERS TO THE EDITORS

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Intranuclear Changes in the Polyhedrosis of *Tipula paludosa* (Diptera)

THE technique of cutting ultra-thin sections for electron microscopy has made it possible to follow the behaviour of certain viruses in the cell, and this is particularly true of the nuclear virus diseases of insects. The present note describes the remarkable behaviour in the nucleus of the polyhedral virus which causes a blood disease in the larva of the fly, *Tipula paludosa*[1]. Sections through blood cells in the early stages of infection show an apparent condensation of the chromatic material in the centre of the nucleus in which the virus rods can be seen developing (Fig. 1). Most of the virus rods at this stage are concentrated in the centre though some occur scattered throughout the nucleus. The virus rods are never observed on the outer side of the nuclear membrane.

As the disease progresses, what is apparently a large thin-walled vesicle develops around individual virus rods which collect in masses on the inner edge of the nuclear membrane. These vesicular masses are apparently held together, probably by a thin membrane (Fig. 2). The vesicles are much less dense than the surrounding medium, and the virus rod in each vesicle is thinner and more sharply defined than the rods remaining outside. The appearance of the vesicle and the fact that each rod is suspended away from the sides suggest that there may be a fluid, possibly a protein solution, inside the vesicles. Next, the edge of the mass nearest the nuclear membrane becomes denser, and the vesicles at this point are apparently compressed and much smaller. As crystallization proceeds all the vesicles become greatly reduced in size, possibly because of the osmotic effect of the medium surrounding them, until each vesicle, empty now of fluid and closely pressed around the virus rod, eventually forms the capsule in which each virus rod in the polyhedral crystal is enclosed. It may be that fluid forced out of the vesicles is used in the crystal formation.

All these changes take place inside the nucleus; but the final position of the completed crystal is outside the nucleus with its inner edge along the nuclear membrane. Apparently as the crystal forms it is forced out of the nucleus until it reaches that position.

The accompanying electron micrographs were taken by S. Vernon-Smith.

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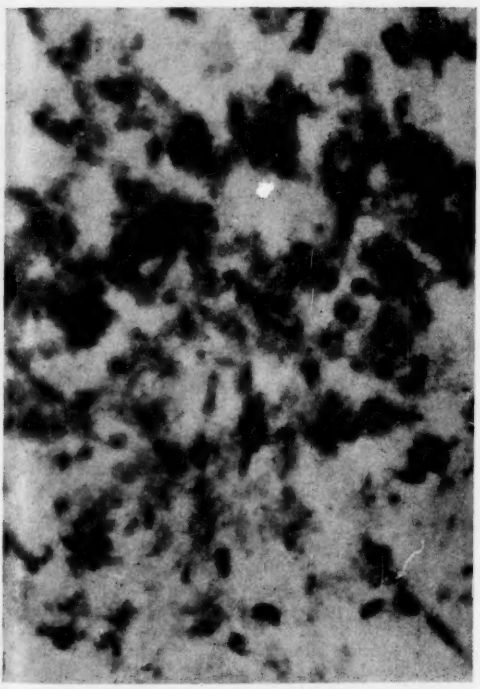

Fig. 1. Thin section through part of the centre of a diseased nucleus, showing the developing virus rods. × 50,000

Fig. 2. Segment of a diseased blood cell, showing the mass of vesicles against the inner edge of the nuclear membrane. × 25,000

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Xanthomycin A

While studying the antibacterial products of a species of *Streptomyces* (N.C.I.B. 8697) sent by Dr. R. Green from Malaya, we have isolated an orange-red coloured basic substance which is very active against a variety of bacteria and is highly toxic to mice. The antibiotic was extracted from the culture fluid into chloroform, at *p*H 6, and re-extracted into water at *p*H 2, or extracted into trichloroethylene, at *p*H 8·5, and re-extracted into water at *p*H 3·5. It was purified by counter-current distribution in a solvent system consisting of trichloroethylene and 0·1 *M* sodium citrate buffer, *p*H 5·95. In this system its partition coefficient, *K* (= concentration in trichloroethylene/concentration in water), was 0·98. The purified product yielded a crystalline hydrochloride, reineckate and picrate. The behaviour of this antibiotic suggests that it is identical with, or very closely related to, xanthomycin *A*—a substance which has been isolated from species of *Streptomyces*[1], and stated to have quinonoid properties[2]. We wish to record, however, that it is a stronger base than xanthomycin *A* has been reported to be and that it yields two simple bases on hydrolysis which have not been described as degradation products of xanthomycin *A*.

A number of properties of the antibiotic from the Malayan *Streptomyces* were similar to (and in some cases virtually indistinguishable from) those reported for xanthomycin *A*. The hydrochloride of the antibiotic ($[\alpha]_D^{30}$ + 100, in water) had an equivalent weight of approximately 540 and gave analytical data which were not inconsistent with the molecular formula $C_{22}H_{29-31}N_3O_7$,2HCl. It showed an ultra-violet absorption spectrum with a maximum at 265 mμ (*E*(1 per cent, 1 cm.) 180) and an infra-red spectrum that was almost identical with one published by Rao and Peterson[2]. The partition coefficient of the antibiotic in the system chloroform–0·1 *M* sodium citrate buffer, *p*H 4·2, was close to unity. The free base, obtained from an aqueous solution at *p*H 6 by extraction with chloroform, yielded a product on evaporation of the solvent which showed absorption maxima at 288 and 455 mμ. On paper chromatograms run with *n*-butanol containing 1 per cent by volume of normal hydrochloric acid, the antibiotic behaved as though it could exist in two forms, with R_F values of 0 and 1·0 respectively, which were interconvertible.

A concentration of 0·002 μgm./ml. of the antibiotic inhibited the growth of *Staph. aureus* (N.C.T.C. 6571) in meat broth, and a dose of 30 μgm., given intravenously, proved lethal to a 20-gm. mouse within three days (Florey, H. W., unpublished experiments). These values appear to be of the same order as the corresponding values reported for xanthomycin *A*.

Xanthomycin *A* has been reported to contain two weakly basic groups with *pK* values of 2·0 and 4·5. Electrometric titration revealed that the antibiotic from the Malayan *Streptomyces* contains basic groups with *pK* values of 3·0 and 7·3 respectively. Below *p*H 9 the titration is reversible. Above *p*H 11 the antibiotic undergoes a rapid irreversible change, resulting in loss of activity, the virtual disappearance of the group with *pK* 7·3, and the appearance of groups with *pK* values of about 9·7 and 4·7 respectively. The presence of a group with *pK* 7·3 in the antibiotic is consistent with the fact that it migrates as a base during ionophoresis on paper in collidine acetate buffer at *p*H 7·0[3], and that its partition coefficient in a trichloroethylene–water system increases rapidly as the *p*H of the aqueous phase is raised from 6 to 8. The fact that it is largely extracted by chloroform, like xanthomycin *A*, from an aqueous solution at *p*H 6, can be attributed to the very high partition coefficient of the free base in favour of the chloroform phase.

The antibiotic gives only a poor ninhydrin reaction, but yields two ninhydrin-positive bases on treatment with 6 *N* hydrochloric acid at 105° for twenty hours. The first base is highly volatile and is indistinguishable from methylamine when subjected to ionophoresis on paper, at *p*H 7·0, or to chromatography on paper in butanol–acetic acid[4]. The second base is less volatile and is oxidized by periodate to yield ammonia. It is easily recovered from hydrolysates, together with the first, by azeotropic distillation with toluene[5]. When subjected to ionophoresis on paper at *p*H 7, or to chromatography on papers developed with butanol–acetic acid or butanol–pyridine–water[6], it is indistinguishable from ethanolamine. Quantitative studies[7] have shown that nearly one mole of the first base and two moles of the second are liberated from one mole of the antibiotic.

Hydrogenation of the antibiotic in the presence of palladium on charcoal resulted in the uptake of nearly three moles of hydrogen. No ethanolamine was detected after hydrolysis of the product of hydrogenation. This suggests that the ethanolamine is not joined to the rest of the molecule by either a normal amide or ester linkage alone, or by both types of linkage. The infra-red spectrum of the antibiotic shows no band corresponding to the CO of a normal ester grouping, but bands at 6·03μ, 8·70μ, 8·98μ and 9·13μ. It is of interest that bands in the region of 8·70μ, 8·98μ and 9·13μ have been reported to be shown by simple oxazolidines and a band in the region of 6·03μ by the corresponding Schiff's bases[8].

We are indebted to the Medical Research Council's Antibiotics Research Station, Clevedon, for supplies of culture fluid and concentrates of the antibiotic.

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Effects of Adenosine Triphosphate and Metals upon an Electron Transport System in Mitochondria

In the course of studies on oxidative phosphorylation coupled with the succinoxidase system of rat-liver mitochondria, it was found that adenosine triphosphate, alone and with certain metals, significantly accelerated reduction of triphenyltetrazolium chloride to triphenylformazan.

Mitochondria were isolated from rat livers by homogenization in 8·5 per cent sucrose and coagulation with 0·15 *M* potassium chloride[1]. The reaction

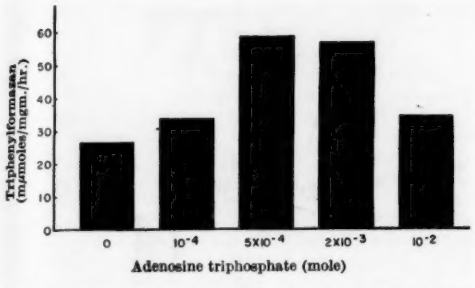

Fig. 1. Effect of varying amounts of adenosine triphosphate on production of triphenylformazan by mitochondria. The reaction mixture totalled 3·0 ml., containing 50 μmoles of potassium succinate, 400 μmoles tris (hydroxymethyl) amino-methane buffer pH 7·4, 1 μmole of triphenyltetrazolium chloride, 0·2 ml. of mitochondria in 0·15 *M* potassium chloride

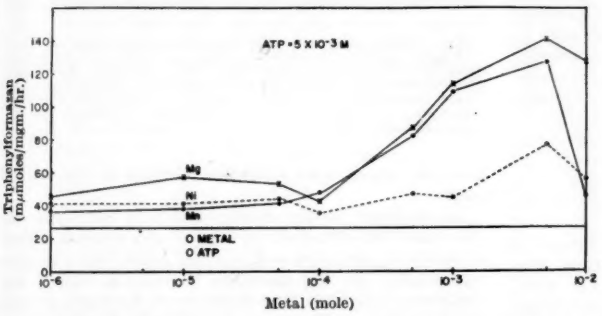

Fig. 2. Effect of varying amount of magnesium, manganese or nickel with a constant amount of adenosine triphosphate on the production of triphenylformazan by mitochondria

proceeded aerobically for sixty minutes at 25° C. without shaking. The protein was precipitated by the addition of 3 ml. of acetone to terminate the reaction and removed by centrifugation; simultaneously, the triphenylformazan was extracted and its concentration was determined at 480 mμ.

The addition of adenosine triphosphate in varying quantities to the reaction mixture produced a marked increase in the reduction of triphenyltetrazolium chloride; similar concentrations of adenosine monophosphate or pyrophosphate had no effects (see Fig. 1). Its effect was maximal at concentrations between 0·5 and 2 × 10^{-3} *M* and statistically significant in a series of experiments. Since the effect of adenosine triphosphate in biochemical systems has been shown to be dependent upon the presence of magnesium or manganese[2], and since mitochondria contain significant amounts of these and other metallic elements (unpublished work with R. E. Thiers), the effect of the addition of a variety of metals with varying amounts of adenosine triphosphate was studied: aluminium, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, molybdenum, nickel, strontium, vanadium and zinc. The effects of the addition of varying amounts of magnesium, manganese or nickel with a fixed amount of adenosine triphosphate is shown in Fig. 2. Fig. 3 shows similar results obtained when varying amounts of adenosine triphosphate were added together with fixed amounts of magnesium or manganese. Significantly, maximal activation of the production of triphenylformazan occurred when metal and adenosine triphosphate concentrations were equal.

Studies on the interaction with other elements showed that calcium, barium, strontium and chromium neither produced additional activation nor interfered with the action of adenosine triphosphate in activating this reduction mechanism. Beryllium, aluminium, zinc, copper, iron, vanadium and molybdenum not only had no stimulating effect but also abolished the stimulation due to adenosine triphosphate itself.

The enhancement of the stimulatory effect of adenosine triphosphate upon reduction of triphenyltetrazolium chloride when magnesium, manganese or nickel were added in equimolar quantities suggests as a working hypothesis that the adenosine triphosphate alone acts in conjunction with the metals of mitochondria. The levels of concentrations of magnesium and manganese in mitochondria support such a hypothesis. The relationship of metal–adenosine triphosphate complexes to electron transport is now under investigation for its implications in the mechanism of oxidative phosphorylation. A similar suggestion, based upon a different experimental approach, has been advanced recently[3]; our attempts to complement this hypothesis by the repetition of Lindberg and Ernster's experiments have failed so far. The substance of this communication will be published more fully elsewhere.

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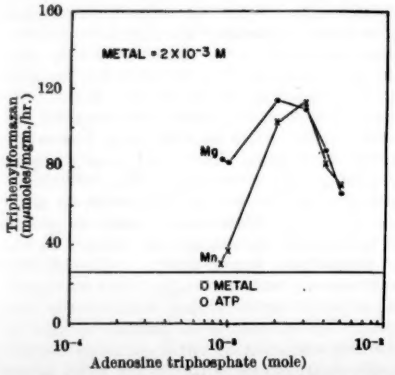

Fig. 3. Effect of varying amounts of adenosine triphosphate with a constant amount of magnesium or manganese on the production of triphenylformazan by mitochondria

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Distribution of Free Amino-Acids in Embryos of *Xenopus laevis*

Recent investigations[1,2] have shown that some of the free amino-acids in amphibian embryos change in concentration during early development. These changes are of interest because they may be related to the synthesis of new, specific proteins[3]. It has been shown that halved embryos of *Rana pipiens* and *Hyla regilla* allowed to develop in a medium containing radioactive glycine or methionine will incorporate these amino-acids directly into protein, and that the rate of incorporation is particularly high in dorsal halves of gastrulæ and neurulæ, which are known to synthesize protein more rapidly than other parts of the embryo[4,5].

The most complete investigation so far published[2] on free amino-acids in amphibia was carried out on whole *Rana pipiens* embryos. These contain free aspartic acid, glutamic acid, glycine, histidine, threonine, arginine, tryptophan and valine. Aspartic acid, glycine, histidine and threonine are present in high concentration at the beginning of development, and their concentration falls sharply during cleavage, rising afterwards to a maximum at the neurula stage. Arginine, tryptophan and valine are present in very low concentration at first, and their concentration rises steadily during development, to reach a maximum in the neurula. No data were given for separate dorsal and ventral regions of the embryo.

Work which is now in progress on embryos of *Xenopus laevis* shows that the whole embryos, like those of *R. pipiens*, contain free aspartic acid, glutamic acid, glycine, arginine and valine; but that, in addition, free glutamine, α-alanine, β-alanine, leucine and cystine are present (Fig. 1). Histidine, threonine and tryptophan, on the other hand, cannot be detected. Aspartic acid and glutamic acid are present in highest concentration, and these show a significant decrease between morula and early gastrula stages. Glutamine, also present in fairly high concentration, shows a significant decrease between late neurula and early tailbud stages. The concentration of leucine increases significantly between early and late gastrula stages, with a further increase at the tailbud stage.

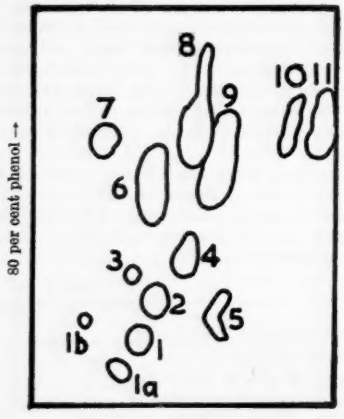

Fig. 1. Map showing the positions taken up on chromatograms by the eleven free amino-acids identified in *Xenopus laevis* embryos. (1) Aspartic acid; (1*a*, *b*) ? glutathione; (2) glutamic acid; (3) ? cysteine; (4) glycine; (5) cystine; (6) glutamine; (7) arginine; (8) β-alanine; (9) α-alanine; (10) valine; (11) leucine

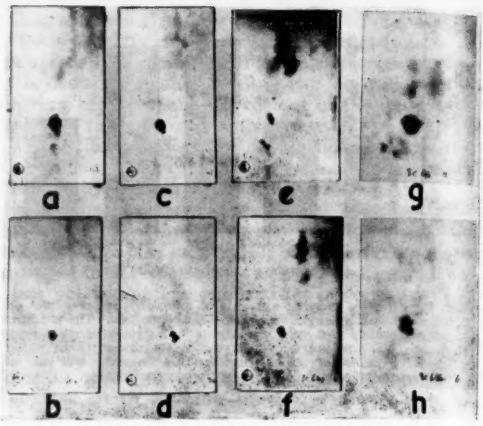

Fig. 2. Chromatograms of the free amino-acids extracted from 10-mgm. samples (frozen-dried weight) of tissue from different regions of the embryo. (*a*) Animal half of blastula; (*b*) vegetal half of blastula; (*c*) dorsal lip of early gastrula; (*d*) remainder of early gastrula after excision of dorsal lip; (*e*) dorsal half of late gastrula; (*f*) ventral half of late gastrula; (*g*) dorsal half of neurula; (*h*) ventral half of neurula (compare with Fig. 1)

In addition to the work on whole embryos, the free amino-acid content of dorsal and ventral regions of blastulæ, gastrulæ and neurulæ have been analysed separately. In the blastula, there is a higher concentration of total free amino-acid (γ/mgm. frozen-dried tissue) in the animal half than in the vegetal half: this difference is particularly marked for aspartic acid. In the early gastrula, the concentration of total free amino-acid is higher in the dorsal lip than in the rest of the embryo. Dorsal and ventral halves of the late gastrula, on the other hand, do not differ significantly in their free amino-acid content. By the late neurula stage the difference between dorsal and ventral halves has reappeared. In particular, aspartic acid, glutamic acid and glutamine are present in significantly higher concentration in the dorsal half. Chromatographs of the free amino-acids in these half-embryos are compared in Fig. 2.

Special precautions were taken throughout to obtain clear, consistent chromatographic results and to avoid all possibility of autolysis in the embryonic tissue. The procedure was as follows: since saline caused streaking of the chromatograms, samples of embryos were collected in distilled water. The embryos that were to be analysed whole were kept alive in this medium by not removing the jelly from them. (Test chromatograms of jelly alone had shown that it contained no detectable amino-acid.) Embryos that were later to be halved had, however, to be demembranated first. This was done as quickly as possible, on groups of not more than twelve embryos, which were then frozen immediately on an ice/salt bath at − 10° C. Batches of embryos prepared by one of the above methods were stored in the deep freeze and then frozen-dried. The frozen-dried demembranated embryos could then be dissected at leisure, at room temperature, without any danger of autolysis. The tissues were ground up in a mortar, and the free amino-acids obtained from them by four successive extractions with 80 per cent ethanol, on an ice-bath. (Previous trials had shown that a fifth extraction with ethanol did not remove any further

amino-acid.) The combined extracts were evaporated to dryness at 60° C. and the residue was redissolved in the minimum 80 per cent ethanol for transfer to 7½-in. squares of Whatman No. 1 filter paper for chromatography. Chromatograms were run two-dimensionally, using as the first solvent 80 per cent (w/v) phenol with 3 c.c. of 30 per cent aqueous ammonia added for every 500 gm. phenol. The second solvent was 70 per cent propanol. The chromatograms were sprayed with 0·5 per cent ninhydrin in absolute ethanol, and the colour developed at 65° C. for twenty minutes. The quantities of individual amino-acids present were estimated by a colorimetric method[6].

Using this technique, it is possible to carry out analyses of the free amino-acids not only in whole embryos but also in different regions representing different tissue primordia. Any regional differences in free amino-acid content which might be related to the early synthesis of tissue-specific proteins can in this way be detected. The results already quoted indicate that at least dorsoventral regional differences do exist: further work on more precisely defined parts of neurulæ, tailbud stages and early larvæ is now in progress.

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Metabolism of Triaryl Phosphates in Rodents

Considerable interest is attached to the metabolism of the compound tri-*o*-cresyl phosphate, which has been shown to inhibit various esterases *in vivo* and which is capable of producing demyelination and paralysis in certain species of animals[1]. Pure tri-*o*-cresyl phosphate exhibits little inhibitory activity against esterases *in vitro*[2,3] and the compound appears to be converted into an active inhibitor in the animal; this conversion can also be effected by incubation with liver slices *in vitro*[3].

It had been shown previously by Gross and Grosse[4] that, two hours after intravenous injection of tri-*o*-cresyl phosphate into rabbits, an amount of cresol ester equivalent to 70 per cent of the administered compound can be recovered from the intestinal tract and an amount equivalent to 50 per cent from the liver of the animal. The amounts of cresol ester present in other tissues were too small to be determined, although a large proportion of the cresol ester is later excreted in the urine[4]. In our experiments we had found an active esterase inhibitor in the urine of rats and rabbits after intraperitoneal injection of tri-*o*-cresyl phosphate[5]. This finding suggested that the cresol esters measured by Gross and Grosse might in fact be reactive derivatives of tri-*o*-cresyl phosphate. We proceeded, therefore, to examine the tissues of the rats for esterase inhibiting activity after intraperitoneal injection of tri-*o*-cresyl phosphate, this compound being readily absorbed from the peritoneal cavity[4].

The tissues were homogenized with four volumes of water, the proteins precipitated by the addition of three volumes of ethanol to the homogenate, and various amounts of the supernatant fluid were incubated with a 1 per cent solution of human serum at 37·5° and *p*H 7·4 for 30 min. Under these conditions, extracts of tissues from normal animals fail to cause any significant inhibition of the pseudocholinesterase of human serum. However, the extracts obtained from the tissues sixteen hours after intraperitoneal injection of 1 ml. tri-*o*-cresyl phosphate per kgm. into adult male rats proved to be strongly inhibitory. The pseudocholinesterase of human serum was 50 per cent inhibited by the addition of the extract from 0·1 mgm. fresh weight of liver or 0·03 mgm. of intestine to 1 ml. of the incubation mixture. No significant inhibition was observed with extracts of brain, while the remaining tissues tested (blood, kidney, pancreas, spleen, lung, testis, salivary gland, Harderian gland and the remaining carcass) all contained small amounts of the inhibitor, 50 per cent inhibition of the pseudocholinesterase being obtained when the extract from 3–4 mgm. of fresh tissue was added to 1 ml. of the incubation mixture. The total inhibitory activity present in the tissue extracts was 3–6,000 times greater than the total inhibitory activity present in the tri-*o*-cresyl phosphate which had been injected; that is, the derivative formed in the animal must be at least six thousand times more active than the original compound as an inhibitor of pseudocholinesterase. Approximately 80 per cent of the total esterase inhibitor was located in the intestinal tract, while 12 per cent was recovered from the liver and 8 per cent from the remainder of the body. These values agree fairly well with the determinations of cresol ester in rabbits reported by Gross and Grosse[4].

The concentration of inhibitor in the liver appears to reach a maximum within 30 min. after the injection of tri-*o*-cresyl phosphate, while the concentration in the intestine increases slowly to reach a maximum after several hours. The hypothesis that tri-*o*-cresyl phosphate is converted into an active inhibitor in the liver, excreted in the bile and reabsorbed in the intestine was confirmed by the fact that the bile of rabbits and intestinal contents from rats and rabbits contain very high concentrations of the reactive inhibitor after injection of tri-*o*-cresyl phosphate. Appreciable amounts of the inhibitor can still be recovered from the liver and intestine 7–10 days after the tri-*o*-cresyl phosphate was administered.

The structure of the reactive derivative of tri-*o*-cresyl phosphate is not known. However, a similar inhibitor of serum pseudocholinesterase can be recovered from the liver and intestine after the administration of triphenyl phosphate. Moreover, Bloch has reported that the esterases of the rabbit can be inhibited *in vivo* by the administration of tri-*o*-chlorophenyl phosphate as well as by tri-*o*-cresyl phosphate[6]. Thus it seems probable that the primary alteration in the structure of the triaryl phosphates leading to the formation of reactive inhibitors *in vivo* is a substitution on one or more of the phenyl rings. By analogy with the results obtained with other aromatic derivatives[7], we would expect that a hydroxyl group is introduced into the *para* position and afterwards converted to a sulphate or glucuronide.

Further examination of the urine and liver preparations obtained in the above experiments has revealed the presence of more than one inhibitor.

The major portion of the inhibitory activity is due to a compound which is soluble in ether and other organic solvents, and unstable in aqueous solution. A small part of the total inhibitory activity is due to a compound which is poorly soluble in ether, and stable in aqueous solution at neutral and at acid *p*H. It is possible that other derivatives may be formed in small amounts[7]. Further experiments on the separation of these compounds are being carried out.

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A New Difference between Live and Dead Spermatozoa

When semen is diluted with a solution of formaldehyde under certain standard conditions of *p*H, temperature and osmotic pressure, dead spermatozoa are agglutinated but living ones are not. This difference between live and dead spermatozoa has been investigated in 103 ejaculates from seven bulls at a commercial insemination centre. Samples from a hundred of these ejaculates were used for insemination, three ejaculates being unsuitable for insemination because of low sperm motility.

The percentage of dead spermatozoa in duplicate samples of each ejaculate was estimated in smears stained with nigrosin-eosin[1]. The staining solution (*p*H 7·2; Δ, $-0.54°$ C. $\pm$ $0.02°$ C.) was used at 37° C. Details of the composition of this new solution and of the buffered formal-saline used here will be published elsewhere. Duplicate samples of each ejaculate were fixed in a buffered isotonic solution of sodium chloride (*p*H 7·0; Δ, $-0.53°$ C.) with added formaldehyde (5 per cent formaldehyde), by adding one drop of semen at 37° C. to each of two tubes containing 3 ml. fixative also at 37° C. After fifteen minutes incubation at 37° C., the samples were allowed to cool to room temperature.

Measurements of the percentage of dead (eosinophil) spermatozoa and of the degree of agglutination were made after a variable period (up to two weeks), following treatment of the sample. The number of dead spermatozoa in a total of a hundred was counted on each of two slides. The degree of agglutination was scored on a unit scale of 1 (minimal agglutination) to 4 (maximal agglutination). The samples were shaken and scored by visual assessment of agglutination using transmitted light. The percentage dead and the agglutination score were estimated independently by different observers.

The relationship between percentage dead spermatozoa and agglutination score was examined by regression analysis. The mean percentage dead spermatozoa was used as one variable, and the combined agglutination scores for each sample pair as the second variable. The analysis was made by Dr. R. C. Campbell, Agricultural Research Council Unit of Reproductive Physiology and Biochemistry, Cambridge.

A highly significant relationship ($p < 0.001$) was found between percentage dead spermatozoa and agglutination score. The mean percentage of dead spermatozoa for all samples was 16·7 (range 3·5–65·0); the mean agglutination score for all samples was 3·4 (range 2–8). The mean percentages of dead spermatozoa in the three ejaculates discarded as unfit for insemination were 65·0, 40·0 and 39·5; the combined agglutination scores were 8, 6 and 6.

This difference between living and dead cells does not seem to have been noted before and it may therefore be of some fundamental interest; but, at the moment, we are more concerned with the following practical implications. In 103 samples of bull semen which, with three exceptions, were judged to be suitable for insemination, there was a pronounced relationship between the proportion of dead spermatozoa and the degree of agglutination after treatment of the semen with formaldehyde. A relationship is known to exist between the fertilizing capacity of bull semen and its content of dead spermatozoa[2]; the agglutinability of spermatozoa by formaldehyde may therefore be a simple and useful criterion of the fertilizing capacity of bull semen.

We wish to thank Dr. R. Aschaffenburg, National Institute for Research in Dairying, Reading, and Lord Rothschild, Department of Zoology, University of Cambridge, for measurements of the freezing points of some of the reagents used, and Mr. J. A. Moss, Avoncroft Cattle Breeders, Ltd., for facilities.

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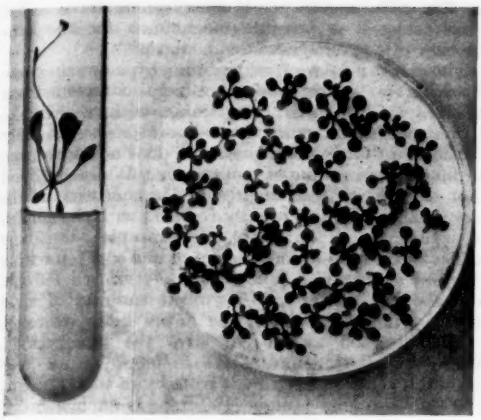
Biochemical Mutations in the Crucifer *Arabidopsis thaliana* (L.) Heynh.

The photosynthetic flowering plants possess a greater capacity for synthesis of crystalloids than any other group of organisms. Their complete exogenous requirements for growth consist of only fourteen elements and the two compounds carbon dioxide and water. No intact flowering plant, with the exception of those lacking chlorophyll, has been shown to require any organic compound apart, of course, from carbon dioxide. I have now attempted to examine plant biosynthesis by the 'mutational block' method, which has been of great success in the analysis of metabolism in haploid micro-organisms.

Selection of mutants deficient in essential syntheses can only be carried out satisfactorily under aseptic conditions, so a necessary prerequisite is an adequate method for the sterile culture of higher plants. In this respect the suitability of the experimental plant



A B

Fig. 1. *Arabidopsis thaliana*. *A*: normal plant, 14 days old, growing aseptically on 5 ml. mineral agar in a 16 mm. × 150 mm. test-tube; nearly full size. *B*: forty-five plants, 13 days old, growing aseptically on cellulose pulp in a Petri dish of 9-cm. diameter; about half-size

is critical, and a search was made for small rapidly growing plants with certain other necessary attributes.

Arabidopsis thaliana (L.) Heynh.[1], a small crucifer with a short life-cycle (28 days), a low chromosome number ($n = 5$), and a high seed output, fitted the requirements reasonably well. In culture, the plants grew well on 5 ml. of medium in ordinary test-tubes and flowered 13–14 days after germination. The medium, solidified with 0·6 per cent agar, contained only the minerals of Knop solution and chelated trace elements. Seeds were sterilized in hydrogen peroxide and ethanol (1 : 1), a method recommended to me by Mr. J. Harris, and transferred to the agar medium with a platinum loop. After a 24-hr. cold treatment to ensure uniform germination, the cultures were placed in a growth chamber maintained at 25° C. and about 800 ft.-candles light intensity.

Plants may be grown on a large scale in Petri dishes containing pure cellulose and mineral nutrients. Contamination was avoided by packing the space about the lid with cotton-wool pretreated with cetyl-pyridinium chloride. The inner surface of the lid may be treated with 'anti-dim' to prevent water condensing in large drops and reducing the available light. When the plants entered the reproductive phase, the Petri dish lid was removed to allow elongation of the flower stalk, flowering and seed-setting. Fifty plants may be grown to maturity in each Petri dish.

The required mutations were induced by X-irradiation[2] (6,000 r., 130 kV.) of seeds, and isolated by growing the segregating (X_2) generations on sterile, chemically defined medium. From 110 X_2 families, twenty-seven mutants have been isolated, nine of these being lethals.

One mutation, inherited as a simple recessive, renders the plant incapable of synthesizing thiamine. Mutant plants have mottled cotyledons, and the subsequent leaves are white or have chlorophyll only at the tips. The block in synthesis, however, is not absolute, for after a lag in growth, which increases in duration as the temperature is raised, the plants become green again and resume growth. All plants die at temperatures above 27° C.; but at 20° C. only 5–10 per cent show any deficiency symptoms. Irrespective of the temperature, all grow normally with 1 μgm. of thiamine per plant. There is some evidence suggesting that the coupling of derivatives of pyrimidine and thiazole to form the thiamine molecule is blocked.

Another recessive lethal mutant, although green, has cotyledons which show early degeneration and the plant dies at the two-leaf stage. When supplied with coconut milk, this mutant will grow slowly and eventually flower. Its specific requirements have not yet been identified.

Three of the lethal mutations prevent the formation of plastids from proplastids. Their effects are apparently not expressed solely as an inactivation of the photosynthetic mechanism, for the plants show no growth response to added sucrose. The formation of chlorophyll is prevented in yet another mutant; but deficient plants will grow slowly and form flowers if sucrose is supplied in the medium. The three remaining lethal mutants have green cotyledons but produce only one pair of very small pale-green leaves. They resemble phenocopies obtained with specific amino-acid antagonists; but no supplement has been found that will improve their growth.

It is to be expected that many mutations blocking metabolism will be eliminated by the sieve of seed development. Thus mutations affecting respiratory processes and the formation of non-diffusible substances necessary for embryo growth will probably not be detected in the X_2 generation. Biochemical genetics in flowering plants is therefore likely to be a more restricted field than its counterpart in the micro-organisms.

A detailed description of these experiments will be published elsewhere. I thank Prof. D. G. Catcheside, in whose laboratory this work was carried out, for helpful criticism and advice; Prof. F. Laibach, of Frankfurt-am-Main, for seeds of *Arabidopsis thaliana* and for generous advice; and the Commonwealth Scientific and Industrial Research Organization for the award of a studentship.

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A New Technique for the Study of Chromosomes of Palms

The study of the chromosomes of palms has always been considered very difficult, as is clearly evidenced by the lack of data on a large number of genera[1]. Even where the number of chromosomes has been recorded, the details of the structure are unknown.

In recent years, the use of a number of pre-treatment chemicals[2,3] has solved to a great extent the problem of karyotype study. But all these are of limited application, appropriate only to certain groups of plant; none of these methods when tried on palms proved to be of any use.

In the study of the cytology of tropical palms which has been undertaken in this laboratory, a number of alkaloids were tested for the fixation of their chromosomes. With one of the alkaloids, namely, æsculine (a derivative of *Aesculus hippocastanum*), excellent results were obtained. Its application in chromosome analysis appears to have solved this long-standing difficulty.

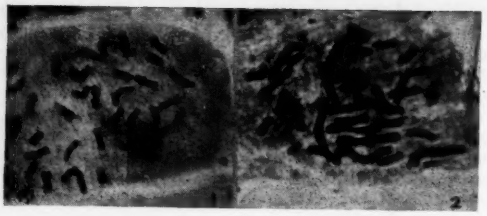

Fig. 1. Somatic metaphase plates of (1) *Oreodoxa regia* H.B. and K., and (2) *Rhapis flabelliformis*, L'Hérit., showing 36 and 34 chromosomes respectively following æsculine treatment

Freshly cut root-tips were treated for different intervals of time at various temperatures, prior to treatment for a few seconds in a mixture of 2 per cent aceto-orcein and *N* hydrochloric acid (9 : 1). Then the tips were smeared in 1 per cent aceto-orcein. Excellent results could be obtained if the tips were treated in a saturated solution of æsculine in water for twenty-four hours, the first two hours being at a temperature of 2°–4° C. and the remainder of the period at 12°–18° C. After treatment, the tips were heated in the dye-acid mixture mentioned above and stained in orcein in the usual way. Application of uniform and sufficient pressure during smearing was very necessary for good results.

The chromosomes come out well scattered with constriction regions distinctly clarified (Fig. 1). So far, about thirty species of palms known to be difficult of analysis have been tried, and the technique proves to be equally effective in all.

The effect of the treatment appears to be principally a change in the plasma viscosity, as suggested by Stalfelt in the case of oxyquinoline[3]. Further, we believe, from the results obtained with a number of chemicals[4], that æsculine to some extent brings about a coagulation of protein—a process which is finally completed by treatment in the dye-acid mixture. Fixation is thus to be attributed to both these steps.

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Hypomagnesæmia in Dairy Cattle and its Possible Relationship to Ruminal Ammonia Production

The highest incidence of hypomagnesæmia in dairy cattle occurs in the first few weeks of the spring grazing which follows the winter stall-feeding period. Some factors which influence its incidence at this time and methods for its control have been studied at this Institute for several years[1]. Recently, we have investigated the changes in blood composition, rumen fermentation and mineral metabolism caused by the transfer to grazing or the feeding of cut spring grass in the stall, and several observations have arisen which suggest a possible mechanism for the production of hypomagnesæmia.

The daily intake of magnesium by a grazing cow receiving no other food or mineral supplement is 20–30 gm., which is comparable with the intake during the stall-feeding period, and it is generally considered that hypomagnesæmia does not arise from an inadequate intake of magnesium. We have found that the excretion of magnesium in the urine of the cow is markedly and rapidly reduced with the change to spring grass. To quote two examples, the daily urinary excretion of magnesium of one cow fell within the first twenty-four hours from 3–4 gm. to 1·5 gm. and then gradually to 0·2 gm. at the end of eight days; while in another, the initial daily excretion of 1·5 gm. fell to 0·1 gm. over the same period. There was a concomitant fall in blood serum magnesium level in both animals from more than 2 mgm./100 ml. to about 1 mgm./100 ml. If such a fall in the urinary excretion of magnesium reflects a reduced intestinal absorption, as observed by McCance and Widdowson[2] in humans, it would indicate that for ruminants the magnesium of spring grass has an unusually low availability. Garner[3] has shown that, *in vitro*, the action of rumen micro-organisms and gastric juice releases the magnesium of grass, so that it would appear that during the early grazing period there is some alimentary disturbance which modifies the availability or absorption of magnesium.

Among the observations made in our rumen studies, a highly significant one, we feel, has been a rise in the ammonia content of rumen liquor, on the transfer to grass feeding, to a continuously high level of 40–60 mgm./100 ml. In contrast, under winter stall-feeding conditions, a general level of 10–20 mgm./100 ml. was found, with peak values of 30 mgm./100 ml. for short periods after feeding. That ammonia production on grass was abnormally high was also reflected by the presence of ammonia in jugular blood, up to 0·3 mgm./100 ml. being observed, indicating that the capacity of the liver for the conversion of portal blood ammonia to urea had been exceeded.

In view of these observations, an attempt was made to influence the absorption of magnesium in cattle receiving a hay and concentrate ration by the addition to the rumen, via a fistula, of ammonium acetate and ammonium carbonate. The daily addition of 1,250 gm. or more of these salts per cow for a period of four days produced ruminal ammonia levels comparable with those observed on grass, and similarly reduced the urinary excretion of magnesium. Smaller additions had no effect. This reduction in magnesium excretion was accompanied by a fall in the serum magnesium from 2·5 to 2·0 mgm./100 ml.

In view of these observations, we feel justified in suggesting that hypomagnesæmia of cows on grass, and particularly during the early spring, arises from an inadequate absorption of magnesium and is probably associated with high ruminal ammonia production. The mechanism is not understood; but it is feasible that ammonia may pass in quantity from the rumen to the small intestine, where an interaction between ammonia and magnesium absorption could take place.

The marked difference in swards in their ability to produce hypomagnesæmia, and the spontaneous recovery in serum magnesium levels of cattle as the grass matures and the nitrogen content falls, might be explained, at least in part, by the critical nature

of the ruminal ammonia-level. The severity of hypomagnesæmia in dairy cattle grazing a given sward would be determined by the animals' individual reserves of magnesium at the end of the winter feeding period, and by the level of their daily requirement.

This series of studies, involving field-trials, balance experiments and studies of rumen digestion, is being continued.

We gratefully acknowledge the collaboration of our colleagues at this Institute in this work.

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Ear Formation in Timothy Grass (*Phleum pratense*) following Vernalization and Short-day Treatments

In many perennial grasses of temperate regions, exposure to low temperature has proved to be a necessary condition for the attainment of the reproductive phase. After vernalization, flowering may occur directly in response to long-day conditions in some grasses[1], or after initial treatment with short days followed by transfer to long photoperiods in others[2,3]. The precise requirements of timothy grass have so far remained unknown, except that it flowers in long days[4] and that spring sowings may lead to ear formation in the same year[3]. In view of the agronomic importance of the plant, some clarification appeared desirable.

Two similar experiments were conducted, one in 1953, the other in 1954. In the first year, seed of *S.*48 timothy, after being vernalized according to the method of Purvis and Gregory[5] for 8, 6, 4, 2 or 0 weeks, was sown in soil on April 10. Immediately on germination one-half of the seedlings in each treatment was exposed to long-day conditions extended to sixteen hours by artificial illumination, while the other half passed through an initial phase of four weeks in short days (eight hours). At the end of this period, both sets of plants were transplanted into pots and placed in a latin square design out of doors under natural day-length conditions. In 1954 the experiment was carried out in the same way, except that vernalization treatments of 16, 8, 4 or 0 weeks were given, after which the seed was sown on April 12.

Table 1. Days to Ear Emergence

Weeks of vernalization	1953* Long-day treatment from germination	1953* Long-day treatment after 4 weeks of short days	
0	93·5	97·9	
2	99·5	94·4	Approx.
4	96·1	90·0	S.E. =
6	88·2	90·9	± 2·70
8	91·8	93·5	
	1954		
0	100·1	112·4	
4	99·8	90·6	Approx.
8	93·8	99·6	S.E. =
16	97·8	99·4	± 4·12

* Weeks converted to days

Table 2. Number of Ears produced per Plant

Weeks of vernalization	1953 Long-day treatment from germination	1953 Long-day treatment after 4 weeks of short days	
0	13·5	10·8	
2	13·5	10·3	Approx.
4	18·2	11·3	S.E. =
6	15·2	12·9	± 1·49
8	12·0	11·1	
	1954		
0	13·9	14·1	
4	14·1	19·0	Approx.
8	11·9	10·9	S.E. =
16	10·9	12·6	± 1·99

Records of ear emergence on the main stem and the first three tillers were kept. The mean number of days to ear emergence on the main stem are given in Table 1.

In both years ears were produced under all treatments, including non-vernalization followed by long-day conditions from germination. Analyses of variance showed no significant differences with vernalization and day-length treatments in the time taken to ear emergence during 1953. In 1954, vernalization appeared to have had some influence, just significant at the 5 per cent level. The effect was, however, not consistent with increasing length of treatment and can scarcely be said to indicate a response to low temperature. No difference with day-length treatment was apparent. Similar relations held if leaf number was taken as a measure of time to ear emergence. Hanson and Sprague[6] have shown that the time taken to differentiation and ear emergence in timothy varies only slightly with temperature during an initial four weeks of short days, but depends mainly on temperature conditions during the long-day period.

During 1953 long-day treatment resulted in a significantly greater number of ears per plant being produced. This was an effect of increased tillering under these conditions, as shown by covariance of ears on number of tillers. Vernalization had no effect in 1953, but in the repeat experiment a significant difference ($p < 0{\cdot}05$) occurred, due apparently to an unusually high figure for one treatment. There was no indication that increasing exposure to low temperature or short-day conditions had led to greater ear production. Evidence that ear-bearing capacity of successive tillers is not entirely controlled by day-length will be presented elsewhere.

Since neither seed vernalization nor initial short-day treatments had any consistent effect, the conclusion seems warranted that timothy grass does not normally require low-temperature exposure or short-day induction for the production of inflorescences.

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Charge acquired by Powdered Salts on moving over Metal Surfaces

One of the common principles of contact electrification is that considerable electrification accompanies the relative motion of two surfaces only if one or both of them has a low electrical conductivity. Dealing with the electrification which occurs when a powder or sand flows down an inclined earthed metal surface, Hudson[1] has shown, by an indirect method, that a typical insulator (zircon sand) acquires a much larger charge than a semiconductor (rutile sand). Hudson's findings were confirmed by measuring directly the charge acquired by these sands from various lengths of an earthed aluminium chute. Fig. 1 shows the results for sands of 114μ average particle size.

The attainment of a limiting charge by the rutile is attributed to the establishment of a balance between the charging action (the nature of which is still obscure[2]) and a recombination of the separated charge caused by leakage due to the conductivity of the rutile[3]. The absence of such leakage with insulator particles allows the extended accumulation of charge, as found with zircon sand. Similar behaviour was found when the electrification was tested of glass microspheres in various states of preparation with respect to adsorbed moisture. Dry microspheres (114μ average diameter) gave a pattern like curve *A*, normal ones a curve of intermediate shape, while microspheres having abnormal adsorbed moisture yielded a curve of the same shape as *B* (cf. Peterson[4] working with atmospheres of different humidities).

Crystals of the common salts not only have an appreciable bulk conductivity at room temperature[5], but ordinary specimens possess, in addition, surface conductivity due to adsorbed moisture from the atmosphere[6]. Conductivity tests showed, for example, that powdered sodium chloride has a much higher order of conductivity than either rutile sand or moist glass microspheres. It might therefore be supposed, *a priori*, that the charge acquired by powdered salts would reach a small maximum after a short traverse. Quite the reverse was found experimentally, for, as

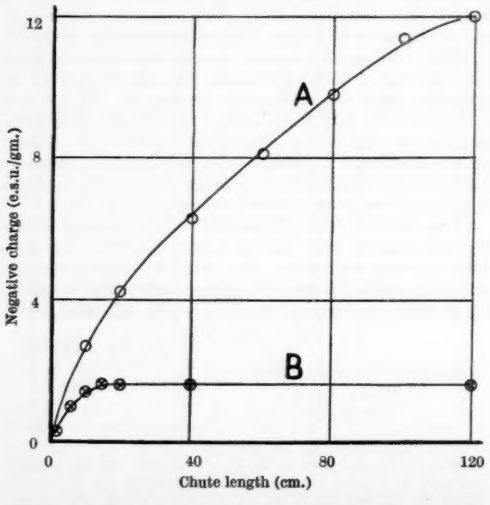

Fig. 1. Charge acquired by 114-μ zircon (*A*) and rutile (*B*) sands from an aluminium chute

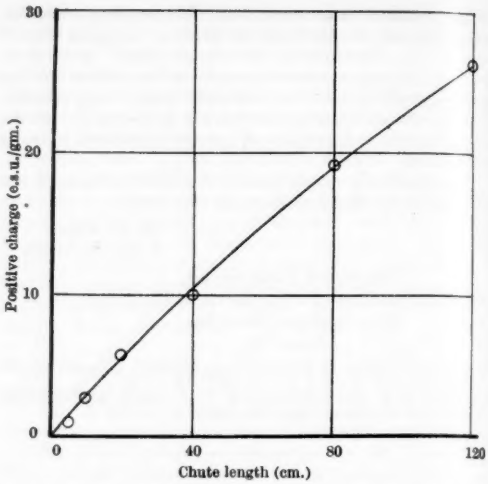

Fig. 2. Charge acquired by 211-μ sodium chloride particles from an aluminium chute

Fig. 2 shows, powdered sodium chloride (211μ average particle size) was electrified intensely by an aluminium chute, and the accumulation of charge with distance showed almost no sign of falling off, despite the high conductivity of the salt. Other ionic compounds gave similar results, both negative and positive electrification being found with different compounds on various metal chutes. The effect of removing the moisture film from powdered sodium chloride (by evacuation for two hours) was to make it acquire a much smaller charge from the aluminium chute, namely, + 5·1 e.s.u. per gram from a 120-cm. traverse compared with + 26·4 acquired by the salt before evacuation.

The magnitude of the tribo-electric effect displayed by salts on metals shows it to be an important electrokinetic phenomenon. The rule that high conductivity leads to only slight electrification is clearly disobeyed. Further experimental work, which is being prepared for publication, suggests that this is due to ion transfer being the governing factor in electrification, whereas the rule has been based on systems involving predominantly electron transfer.

I wish to thank Prof. M. B. Donald for his interest in, and encouragement of, this work, which was carried out at the Ramsay Laboratory, University College, London. The South African Council for Scientific and Industrial Research provided financial assistance, and Messrs. British Titan Products, Ltd., gave the mineral sands used.

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Thermal Expansion of Coal

THE physical properties of coal have not yet been adequately studied. Consequently, proposed models of coal structure cannot be tested nor apparently conflicting experimental observations reconciled. We advocate that accurate measurement of such properties of coal as the thermal expansion, electrical conductivity, and response to mechanical stress should be made concurrently with chemical and physical researches which seek to elucidate the structure of the material in increasingly specific terms.

Accordingly, we have made preliminary measurements of the coefficient of thermal expansion of a limited range of British bright coals in a direction parallel to the bedding plane and normal to the main cleat over the temperature range 77°–293° K.

Changes in the length of small coal lumps have been measured by a capacitance method which has been chosen as sufficiently accurate and convenient in the first instance. The condenser assembly consists of a fused quartz plate upon which rests a short cylinder of the same material bearing the upper condenser plate, a circular copper disk 30 mm. in diameter with three lugs. Resting upon the quartz plate and within the cylinder is a disk of copper upon which stand three like coal specimens supporting the lower condenser plate. The whole assembly is contained within a vessel which can be evacuated and chilled. The coal specimens are cut from bright clarain in the form of tetrahedra 10 mm. high the bases of which are parallel to the main cleat. We have not yet measured the coefficient of thermal expansion parallel to the main cleat or normal to the bedding plane. The capacity change resulting from a change in the temperature of the coal specimens has in these experiments been measured by a commercial instrument in which the incremental capacity can be caused to occupy the whole of the measuring scale.

The measurements relate to dry coal, the specimens having been exposed over magnesium perchlorate for thirty-six hours before use and the vessel containing the complete electrode assembly maintained at 10^{-1} mm. mercury for the twelve hours before the introduction of nitrogen (15 mm. mercury) in readiness for initial measurement and chilling. The observations made have included the change in linear dimension on chilling from room temperature to 77° K. and, using a series of refrigerants, during warming from that temperature to room temperature.

Our results for four British bright coals, including a sample of anthracite (sample *D*), are in Table 1. These supplement the few published values of which we are aware, namely, $20{\cdot}78 \times 10^{-6}$ for anthracite[1] and 42×10^{-6} for a low-rank bituminous coal[2] (carbon content 82·6 per cent dry mineral-free basis).

Table 1. COEFFICIENT OF EXPANSION IN THE BEDDING PLANE OF BRIGHT COAL ($\times 10^{-6}$)

Coal	*A*	*B*	*C*	*D*	
Carbon, per cent dry, mineral-free basis	82	87	90·5	94·5	
Temperature range (° K.):					
293– 77	40	51	36	51	22
77– 90	35	32	42	54	12
90–217	43	40	47	23	8
217–273	42	—	31	49	36
273–293	35	49	59	31	—

The mean values for the full temperature range are probably accurate to $\pm 2 \times 10^{-6}$. The error in the values ascribed to intermediate temperature ranges may be somewhat larger. We are aware of imperfections in both the method and the apparatus. These we hope to reduce. Nevertheless, the values stated are sufficiently accurate to be useful.

The similarity between the observed values for the three bituminous coals (*A*, *B* and *C*) suggests that the differences in the arrangement of solid and space which are consequent upon the change in rank from low-rank non-caking to coking coal have been almost offset by changes in the properties of the solid. The wide range in the values obtained with two sets of anthracite specimens (*D*) reflects the anisotropy of the material.

We do not doubt that if such data had been available a few years ago the inappropriate over-simplification of such a model for coal as that of Bangham[3] would quickly have been apparent.

We hope to continue our measurements with increasing accuracy and completeness.

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F-Centres in Metaphosphate Glass

A NUMBER of investigators[1] have shown that glass on exposure to radioactive and X-radiation becomes coloured. Sheline, Sharp and Arner[2] suggested that this may be due to *F*-centres similar to those produced in alkali halides when bombarded by X-rays and cathode rays. Yokota[3] found that *F*-centres could be created in fused silica and α-quartz by X-irradiation. He further showed that alkali silicate and borate glasses become coloured on X-irradiation due to formation of *F*-centres[4]. Przibram[5] showed that *F*-centres could also be created in borate glass by β- and γ-irradiation from radium.

I have found that *F*-centres can be produced very easily in metaphosphate glass by X-irradiation from a copper target (30 kV., 15 m.amp.). These metaphosphate glasses were prepared by heating sodium dihydrogen phosphate in a platinum tray at 900° C. for 1 hr. Variation in the composition of the glass could be introduced by heating mixtures of sodium dihydrogen phosphate and disodium hydrogen phosphate, and mixtures of sodium dihydrogen phosphate and ammonium dihydrogen phosphate. In the first case, sodium was in excess of the stoichiometric composition, while in the second case phosphate radical was in excess, ammonia disappearing during heating. Composition, however, could not be varied over a wide range, for metaphosphate glass with higher sodium content tended to crystallize out rather quickly.

Absorption spectra measurements were carried out with glass plates (0·8 mm. thick) in a Beckman spectrophotometer model *DU*. The irradiated glass system showed two peaks in the visible region at 510 mμ and 490 mμ respectively, and one in the

ultra-violet region at 340 mμ. With increase in sodium concentration in the glass, the intensity of absorption in the visible region increased, with slight shift towards longer wave-length, but that in the ultra-violet region was more or less unchanged.

These facts indicate that the visible band is due to electrons trapped at negative ion vacancies, and the ultra-violet band is probably due to trapped holes at positive ion sites. Comparing the absorption spectrum of metaphosphate with those of borate and silicate glasses, it is noted that the positions of ultra-violet and visible region bands in all three glass systems are the same, suggesting some similarity in the trapping mechanism in all these cases.

Schulman[6] has shown that metaphosphate glasses in which aluminium, barium, silver, etc., have been dissolved can be used as dosimeters for γ-rays by their radio photoluminescence. This phenomenon can be explained as the production of *F*-centres, and Schulman attributed this to the activating influence of the added metal present in the glass. The present communication shows that *F*-centres can be produced very easily without these activators.

Thanks are due to Mr. S. Bhattacharyya for his help.

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Effect of Chelating Agents on Heterogeneous Catalysis

Chalk and Smith[1] have recently reported that the autoxidation of *cyclo*hexene, catalysed by dissolved heavy metal soaps, is accelerated by chelating agents. It has been discovered in this laboratory that chelating agents may also increase the rate of autoxidation which is heterogeneously catalysed by metallic copper.

The rate of oxygen absorption by transformer oil was compared with that by transformer oil containing 0·25 weight per cent of chelating agent, both in the presence and absence of solid copper. The chelating agents used were α,α′-dipyridyl, disalicylal ethylenediamine, and 'Versenes' 123, 123*a* and 123*b* (the 'Versenes' are commercial, oil-soluble chelating agents and are reported to be amino-acetic acids substituted with long alkyl chains).

Oxidation tests were carried out by placing 10-ml. samples of the oil in Sligh flasks, filling the flasks with oxygen to a pressure of about 800 mm. mercury, and connecting each flask to a manometer. The course of the autoxidation was followed by measuring the decrease of pressure while the flask was kept at 120° C. The copper catalyst used consisted of 35 turns of No. 18 electrolytic copper wire wound on a 0·21-in. diameter mandrel. The transformer oil used was not entirely free from traces of heavy metals, since analysis revealed that it contained 0·1–0·2 p.p.m. of dissolved copper.

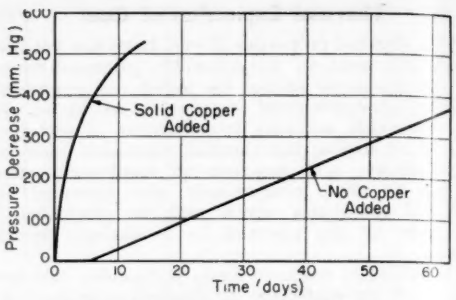

Fig. 1. Oxygen absorption of transformer oil

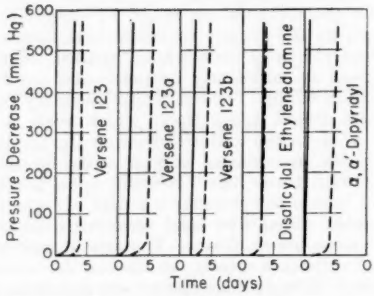

Fig. 2. Oxygen absorption of transformer oil with 0·25 per cent chelating agent: ———, solid copper added; – – – –, no copper added

The results shown in Figs. 1 and 2 confirm the fact that chelating agents will accelerate homogeneous autoxidation and also show clearly, particularly in the case of α,α′-dipyridyl, that they may also accelerate the heterogeneously catalysed reaction.

It will be noted that, for several chelating agents, the addition of the chelating agent to oil in contact with solid copper results in an induction period of several days before rapid oxidation commences. Thus, although these materials are powerful pro-oxidants for heterogeneous catalysis, if observations are confined to the initial stages of the reaction, they will appear to be antioxidants.

I am indebted to the Alrose Chemical Company for a sample of disalicylal ethylenediamine and to the Bersworth Chemical Company for samples of their 'Versenes'.

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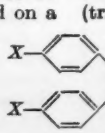
A New Group of DDT Synergists

In a study of the influence of structural variations on the insecticidal activity of DDT, the diaryl-(trifluoromethyl)-carbinols



C—CF_3 (*X*=H, F, Cl, Br, OCH_3, OC_2H_5, CH_3, NO_2)

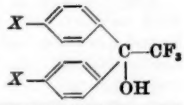
have been prepared by reaction between ethyl trifluoroacetate and the appropriate arylmagnesium bromides; the dinitro-derivative has been synthesized by nitration of the diphenyl compound[1]. The insecticidal potency of the new compounds was practically nil, only the *p*-dichloro-compound exhibiting a slight activity.

Larvicidal tests were somewhat more satisfactory. For these tests the contact toxicity for third-stage larvæ of *Musca vicina* Marq.[2] was compared with that of γ-benzene hexachloride and di-(*p*-chlorophenyl)-methylcarbinol; the percentage of normal pupæ and adults emerging from the larvæ was determined (Table 1).

Table 1

	Concentration (gm./sq. m.)	Normal pupæ (per cent)	Normal adults (per cent)
Di-(*p*-chlorophenyl)-(trifluoromethyl)-carbinol	1·0	56	6
	0·5	85	66
Di-(*p*-chlorophenyl)-methylcarbinol	1·0	90	52
	0·5	92	81
γ-Benzene hexachloride	1·0	2	1
	0·5	3	2
Control	—	96	85

Table 2.
SYNERGISTIC ACTIVITY OF THE CARBINOLS



Carbinol, *X* =	$\frac{\text{DDT}}{\text{Carbinol}} = 10:1$	$\frac{\text{DDT}}{\text{Carbinol}} = 1:1$
Cl	15	25
F	10	16
Br	12	16
OCH_3	5	12
NO_2	4	10
OC_2H_5	0	4
CH_3	0	4

The above carbinols have, however, proved to be excellent synergists for DDT. Benzene solutions of DDT and the synergist were topically applied (microloop method) to groups of twenty-five representatives of a laboratory strain of *Musca vicina* only slightly resistant to DDT (strain *A*) and of a selected strain (*B*), fourteen times more resistant than strain *A*. Mortalities were determined after 24 hr. The synergistic activities (a synergistic activity of *n* means that it is possible to reduce the dosage of DDT to 1/*n* without decreasing the effect) observed for strain *A* are shown in Table 2.

For strain *B* all these figures were approximately ten times higher. Comparison with some of the most active synergists known[3] show that di-(*p*-chlorophenyl)-(trifluoromethyl)-carbinol is 2·5 times more active than di-(*p*-chlorophenyl)-methylcarbinol, 2·0 times more than di-(*p*-chlorophenyl)-methyl chloride and 1·5 times more than 1,1-di-(*p*-chlorophenyl)-ethane.

The close structural analogy between DDT and its most potent synergists is noteworthy. Adopting the theory of the mode of action of the insecticide which has recently been proposed by Gunther *et al.*[4], one may assume that the synergists occupy preferentially the site at which DDT is metabolized and thereby inactivated. The synergists would thus prevent the inactivation reaction and appear to bear the same relation to the insecticide as an antimetabolite to the normal metabolite. Similar theories of 'competition by displacement' have been suggested for the phenomenon of synergism by Perry *et al.*[5], and by Speroni and co-workers[6].

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Ester Groups in Lignin

THE main high-molecular phenolic constituent of woody plant tissues, lignin, is partly soluble in neutral organic solvents. The methanol-soluble fraction known as 'native' lignin generally shows an ultra-violet absorption spectrum with strong end-absorption and weakly resolved bands at 280 and 350 mμ[1].

The native lignin from sugar cane differs from other lignin in this respect, having a distinctive ultra-violet absorption spectrum (Fig. 1). This has been attributed to the presence of substituted *p*-hydroxyphenylketone groups[2]; but it has now been shown that these distinctive absorption bands are due to the presence of *p*-hydroxycinnamic ester groups. This is only the second time that ester groups have been reported in a lignin (cf. ref. 3).

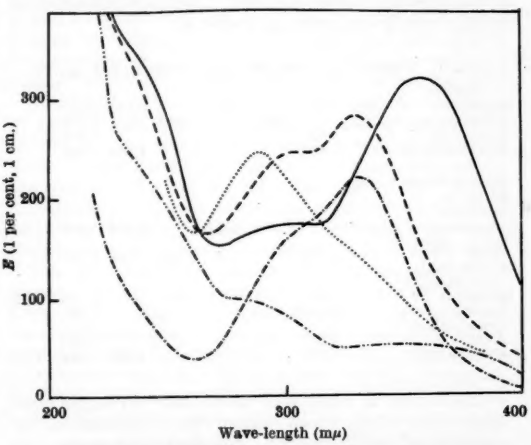

Fig. 1. Ultra-violet absorption spectra of fractions from sugar cane native lignin in aqueous sodium hydroxide
———, Lignin in 0·01 *N* sodium hydroxide; – – – –, lignin in *N* sodium hydroxide after standing 4 hr. at room temperature (*A*); . . . . . , lignin in *N* sodium hydroxide after standing two days at room temperature; – · – · – ·, material extracted from (*A*) at *p*H 4 by ether; spectrum measured in *N* sodium hydroxide; – · · – · · – · · –, material not extracted from (*A*) at *p*H 4 by ether; spectrum measured in *N* sodium hydroxide

Whereas in aqueous 0·01 *N* sodium hydroxide the absorption spectrum of sugar cane native lignin is unchanged for many hours, in *N* sodium hydroxide the absorption maximum at 355 mμ moves to 330 mμ over a period of about four hours, and a subsequent slower process results in replacement of the two maxima at 300 and 330 mμ by a single maximum at 290 mμ (Fig. 1). *p*-Hydroxycinnamic acid (33 mgm.) was isolated from a solution of lignin (300 mgm.) at the end of the first process of transformation in alkali, by acidification, extraction with ether and recrystallization from water. The acid was further purified by vacuum sublimation (melting point 211–212° decomp., undepressed on admixture with an authentic sample. Found: C, 66·3; H, 5·2; calc. for $C_9H_8O_3$: C, 65·9; H, 4·9 per cent).

The initial transformation of sugar cane native lignin in alkali is paralleled closely by the hydrolysis of methyl *p*-hydroxycinnamate (absorption maximum at 353 mμ in dilute alkali), suggesting that a similar ester linkage is present in the lignin. The later stage of transformation in alkali receives a partial explanation in that *p*-hydroxycinnamic acid decomposes in *N* sodium hydroxide to give a single absorption band at 290 mμ. Paper chromatography of the ether extract at the end of the initial stage of transformation showed the presence not only of *p*-hydroxycinnamic acid, but also of small amounts of *p*-hydroxybenzoic acid, vanillic acid, syringic acid and ferulic acid.

Native lignins from wheat straw, Douglas fir wood and horse chestnut wood were examined for comparison. Only with wheat lignin does the absorption spectrum show appreciable hydrolytic transformation in *N* sodium hydroxide, and paper chromatography of the ether extract showed the presence of *p*-hydroxycinnamic acid and ferulic acid, accompanied by traces of vanillic acid and syringic acid. Douglas fir lignin yielded traces of *p*-hydroxybenzoic acid and vanillic acid; horse chestnut lignin yielded traces of vanillic acid, *p*-hydroxycinnamic acid and ferulic acid.

The infra-red spectra of these lignins in the region 5·5–6·5μ provide additional evidence for the presence of ester groups in two of them. The absorption bands in this region are given in Table 1.

Table 1. Position of Infra-red Absorption Bands (cm.$^{-1}$)

Lignins							
Sugar cane	1,695	1,662		1,621		1,597	1,585
Wheat straw	1,697		1,645		1,612	1,599	1,587
Douglas fir		1,657		1,624			1,589
Horse chestnut		1,660				1,590	1,584
Model substances							
Methyl *p*-hydroxy-cinnamate	1,694			1,621		1,598	1,581
Ferulic alde-hyde		1,660			1,611	1,593	1,581
3 : 4-Dimeth-oxycinnam-aldehyde		1,661			1,611		1,588 1,575
Vanillin		1,670					1,586
Veratric alde-hyde		1,667					1,588
Acetovanillone		1,657				1,591	1,582

The bands at 1,695 and 1,697 cm.$^{-1}$ in sugar cane lignin and wheat straw lignin can be allocated, by comparison with methyl *p*-hydroxycinnamate, to ester-carbonyl stretching vibrations. Likewise the bands at 1,657–1,662 cm.$^{-1}$ in the lignins are probably due to aldehyde or ketone stretching vibrations. These spectra were obtained with a single-beam spectrometer using 10 per cent and 7 per cent solutions of lignins and model substances respectively, in dioxan. A thickness of 0·01 mm. of solution was used and the band of dioxan at 5·8μ was eliminated by subtraction.

It appears from the nature and distribution of ester residues in these cases that ester residues are attached to pre-formed lignins, and so do not throw light on the basic structure of these substances.

This work forms part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research.

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Colorimetric Determination of Micro Quantities of Calcium

The reaction of murexide (ammonium purpurate) with calcium ions to give the colour-change purple to red has long been known. It was recently studied spectrophotometrically in detail by Schwarzenbach and Gysling[1]. As a result of this work, Ostertag and Rinck[2] proposed a method for the colorimetric determination of calcium. They chose to work at *p*H 6·2, where the colour is very stable. We have found, however, that if the determinations are carried out at *p*H 11·0 (using potassium or sodium hydroxide), the colours are sufficiently stable (no appreciable change in 15 min.) to be readily determined, while the sensitivity of the method can be increased at least fifty times. Thus, quantities of calcium in the range (0–8) μgm./10 ml. can be readily estimated. At *p*H 6·2 the method is quite insensitive over this range.

The murexide solution was prepared fresh daily and contained 20 mgm./l.

The red colour due to the calcium was determined against distilled water on a Hilger Spekker absorptiometer using the Ilford spectrum blue-green filter No. 603 and 1-cm. cells. (At higher calcium concentrations, the loss in the blue colour of the murexide may be determined using the spectrum yellow filter No. 606.)

A known volume of calcium solution was added to 1 c.c. of 0·03 *N* potassium hydroxide and the solution made up to 5 c.c. with distilled water. 5 c.c. of murexide was added immediately before determining the colour.

Fig. 1 shows the linear relationship between the colour and concentration of calcium. This curve is reproducible, and the colour-change over the range (0–8) μgm. Ca^{2+}/10 ml. is quite considerable.

Ammonium, sodium, potassium, aluminium and manganese ions, when present in twenty-fold excess (on a molecular basis) over the calcium, do not show any interference with the colour due to the calcium. A similar result is obtained with barium ions in ten-fold excess.

There is considerable interference from copper, zinc, cadmium, mercuric, silver and cobalt ions even when present in comparable amounts to the calcium. Under the latter conditions of concentration,

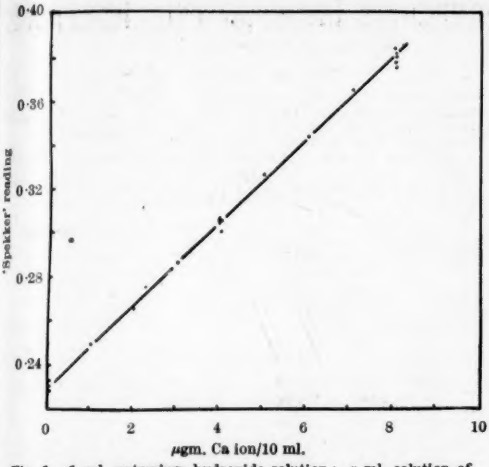

Fig. 1. 1 ml. potassium hydroxide solution; x ml. solution of calcium; distilled water to 5 ml. plus 5 ml. murexide solution (20 mgm./l.). Final pH, 11·2

strontium and magnesium ions give a result which is 10 per cent too high, while ferrous and ferric ions give a result 4–5 per cent too low.

The use of potassium cyanide ($\sim$ 1 gm./l.) in the potassium hydroxide completely eliminated interference from copper, mercuric, silver, cobalt and cadmium ions. The effects due to zinc, ferrous, ferric, strontium and magnesium ions are largely unaffected.

We wish to thank the Directors of the County Laboratories, Ltd., for permission to publish this communication.

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Cellular Electrolytes and Adrenal Steroids

It has long been established that deficiency in adrenal cortical hormones can give rise to loss of intracellular sodium, and that excess of these hormones leads to a retention of sodium and water by tissue cells, with a loss of intracellular potassium.

The distribution of electrolytes between red cells and plasma in Addison's disease and Cushing's syndrome has been investigated in this laboratory. In three cases of Addison's disease the plasma sodium was lowered and the potassium raised; but in the red cell these electrolytes remained unchanged. The results of the red-cell analyses were not unexpected, since the cellular electrolytes of adrenalectomized animals remain normal unless the animals are maintained on water only. In two cases of Cushing's syndrome the plasma sodium was found to be normal and the potassium-level depressed; again, the red-cell content of both sodium and potassium was normal. It is highly probable that the rates of movement of sodium and potassium across the red-cell membrane are significantly influenced by adrenal steroids, and Streeten and Solomon[1] have demonstrated that corticotrophin (ACTH) or cortisone administered to patients caused a slowing of the rate of influx and efflux of potassium across the red-cell membrane, without leading to the anticipated net loss of cellular potassium. Furthermore, hydrocortisone *in vitro* produced a similar response.

To test whether the human erythrocyte was suitable for the investigation of hormone effects on electrolytes, the following *in vitro* experiment was carried out. Human blood was heparinized and cold-stored at 4°–6° C. for six days. During this period the red-cell sodium concentration doubled, the potassium fell and water increased. The cold-stored cells were next incubated for 3–5 hr. at 38° C. in a Krebs–Ringer bicarbonate buffer. Glucose was added to all samples, and deoxycorticosterone was used to test the influence of adrenal steroids on the active transport of sodium. In samples incubated with glucose alone, there was a considerable extrusion of sodium and water by the red cells. The effect of added deoxycorticosterone was significantly to inhibit this active transport. During the incubation period the red cells gained potassium, a gain which was not found in the presence of deoxycorticosterone. The results of a typical experiment are given in Table 1.

Table 1. Effects of Deoxycorticosterone on Active Sodium Transport in Human Red Cells

Incubation carried out at 38° C. in Krebs–Ringer bicarbonate, pH 7·4; gas phase 5 per cent carbon dioxide in oxygen. Glucose concentration 0·01 *M*. Time 3·0 hr.

	Sodium (m.equiv./l. cells)	Net sodium change	Potassium (m.equiv./l. cells)	Water (gm./l. cells)
Cold-stored red cells	46·0		70·0	740
Red cells incubated with glucose	34·0	12·0	76·0	728
Red cells with glucose and deoxycorticosterone	41·0	5·0	70·0	734

The effect of deoxycorticosterone on cellular electrolytes was therefore to inhibit the active transport of sodium from the cells; it might, therefore, be expected to give rise *in vivo* to pathological retention of sodium and water. It has previously been found to have a similar action on yeasts[2] and on rat tissues by Schatzmann[3]. Cortisone has been found to be without influence on the sodium transport of human red cells (Maizels, personal communication).

It is generally believed that the active transport of ions in tissue is dependent on the energy metabolism of the cell, and there is some evidence to show that adrenal steroids influence the electrolyte distribution by means of their effect on energy metabolism. The observations reported above may facilitate the study of hormone activity, electrolyte distribution and energy metabolism in human cells.

The investigations recorded above are part of a research programme suggested by Sir Henry Cohen. The use of deoxycorticosterone was suggested by Dr. I. Chester Jones (Liverpool) and the drug kindly given by Ciba Laboratories. I wish to acknowledge discussions with Prof. H. A. Krebs and his colleagues, Prof. M. Maizels and Prof. C. H. Gray. Skilled technical assistance was given by Mrs. Anne Chambers.

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April 1.

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FORTHCOMING EVENT

Wednesday, August 10—Friday, August 12

Faraday Society (in the University Laboratory of Physiology, Parks Road, Oxford)—General Discussion on "The Physical Chemistry of Enzymes".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Physicists (with a university degree or equivalent qualification in physics) at the Research Laboratories, Central Electricity Authority, Leatherhead, for duties which include research on problems associated with the generation and transmission of electricity—Director of Establishments, Central Electricity Authority, Winsley Street, London, W.1, quoting AE/643 (August 10).

Lecturer (preferably with special qualifications in micro- and semi-micro- analytical techniques) in Chemistry—The Secretary, The University, Aberdeen (August 20).

Divisional Chief Scientist (fully qualified in one of the pure or applied sciences (chemistry, physics, chemical engineering or fuel technology), and good industrial or research experience)—National Coal Board, Secretariat (E), Cambrian Buildings, Mount Stuart Square, Cardiff (August 24).

Head of the Physics Department—The Principal, Derby Technical College, Normanton Road, Derby (August 29).

Assistant in Natural History—The Secretary, The University, Aberdeen (August 31).

Assistant Lecturer or Lecturer (with a degree or diploma in horticulture and experienced in ornamental horticulture and landscape gardening) in Horticulture, at Canterbury Agricultural College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, August 31).

Demonstrator in the Department of Inorganic Chemistry—The Registrar, King's College, Newcastle-upon-Tyne (August 31).

Senior Lecturer in Anatomy—The Dean of the Medical College, St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (August 31).

Research Assistant (with a physics degree) in the Geophysics Section of the Geology Department—The Professor of Geophysics, Imperial College of Science and Technology, London, S.W.7 (September 1).

Lecturer (preferably with an interest in algae, especially marine algae) in the Department of Botany at the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Cape Town, September 2).

Lecturer in Sociology—The Registrar, The University, Hull (September 3).

Assistant Lecturer in Metallurgy—The Registrar, The University, Manchester 13 (September 7).

Edward A. Deeds Senior Fellow for research in engineering, metallurgy, chemistry, physics, mathematical physics or any cognate subject—The Secretary, Deeds Fellowship Committee, Queen's College, Dundee (September 7).

Lecturer in Engineering—Joint Clerk to the University Court, Queen's College, Dundee (September 15).

Lecturer (with a good honours degree in metallurgy) in Metallurgy—The Registrar, College of Technology, Manchester 1 (September 15).

Lecturer (graduate in science or technology, and a good knowledge of the theory of structures) in Structural Engineering—The Registrar, College of Technology, Manchester 1 (September 19).

Reader in Soil Science—The Registrar, University Registry, Oxford (September 29).

Director of Adult Education at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

Professor of Metallurgy at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

Chair of Botany at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, October 15).

Assistant Lecturer (Grade A) in the Department of Applied Physics—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1.

Demonstrator in Physics—The Registrar, The University, Nottingham.

Field Studies Instructor (with a degree in geography or a general science degree, and preferably some teaching experience) at Glenmore Lodge, Scottish Centre of Outdoor Training, Aviemore, Inverness-shire—The Secretary, Scottish Council of Physical Recreation, 4 Queensferry Street, Edinburgh 2.

Plant Breeder, Scientific Officer, Senior Scientific Officer or Principal Scientific Officer grade (with at least a second-class honours degree and experience in plant breeding), in the West African Maize Rust Research Unit, Nigeria, to carry out research into maize rust—Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.197/376/01.

Scientific Officers (with a first- or second-class honours degree, or equivalent, in mathematics, physics or economics) with the Air Ministry, for operational research in or near London—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.384/54A.

REPORTS and other PUBLICATIONS

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Great Britain and Ireland

The Growth-Stages of the Pouch-Young of the Native Cat (*Dasyurus viverrinus*), together with Observations on the Anatomy of the New-Born Young. By the late J. P. Hill and W. C. Osman Hill (From the *Transactions of the Zoological Society of London*, Vol. 28, Part 5). Pp. 349–452+13 plates. (London: Zoological Society of London, 1955.) [16]

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